Iron and Steel Engineer

Established 1907 as Proceedings of A. I. & S. E. E.

J. F. KELLY, Editor

CONTENTS

Volume VI. NOVEMBER, 1929 Number XI.

Modern Blast Furnace Theory and Practice—By Ralph H. Sweetser and S. P. Kinney..... 575

Physical and Chemical Conditions in the Interior of the Blast Furnace—By S. P. Kinney..... 579

Power Economy—By R. M. Fuller. Discussion presented by F. O. Schnure, M. J. Conway and R. M. Fuller.... 584

Electricity a Factor in Reduced Rolling Costs—By C. M. Thompson, Jr. Discussion presented by F. O. Schnure, R. F. Gale, J. G. Walz, Walter Burr and C. M. Thompson, Jr..... 587

Smoke Abatement In Industry—By Martin J. Conway. Discussion presented by H. K. Hardcastle, M. J. Conway, F. O. Schnure, N. C. Bye.. 589

Fabricated Direct Current Machines—By R. S. Marthens and F. T. Hague. 592

Inspection Trip Pittsburgh and Cleveland District Sections A. I. & S. E. E. 597

High Voltage Safety Rules..... 600

Machine Shop Safety Rules..... 601

Locomotive Crane Operators and Brakemen Safety Rules..... 602

Items of Interest..... 603

Coming Meetings and Papers..... 11

Editorial 111

List of Advertisers..... IV

Published Monthly by

Association of Iron and Steel Electrical Engineers

BOARD OF DIRECTORS—1929-1930

PRESIDENT, F. W. CRAMER, Republic Iron and Steel Co., Youngstown, Ohio

FIRST VICE PRESIDENT, R. M. HUSSEY—Jones & Laughlin Steel Corp., Aliquippa, Pa.

SECOND VICE PRESIDENT, F. O. SCHNURE—Bethlehem Steel Co., Sparrows Point, Md.

TREASURER, JAMES FARRINGTON—Wheeling Steel Corp., Steubenville, Ohio.

SECRETARY, W. E. MILLER—Bethlehem Steel Company, Johnstown, Pa.

PAST PRESIDENT, C. S. PROUDFOOT—Vanadium Corp. of America, Niagara Falls, N. Y.

PAST PRESIDENT, A. J. STANDING—Bethlehem Steel Company, Bethlehem, Pa.

DIRECTOR AT LARGE, S. S. WALES—Carnegie Steel Company, Pittsburgh, Pa.

DIRECTOR, F. E. LEAHY—Youngstown Sheet & Tube Company, Youngstown, Ohio.

DIRECTOR, WALTER GREENWOOD—Youngstown, Ohio.

DIRECTOR, G. A. LAMBERTON—National Tube Company, Lorain, O.

DIRECTOR, L. C. EDGAR—Carnegie Steel Company, Braddock, Pa.

DIRECTOR, J. J. BOOTH—National Tube Company, Gary, Indiana.

DIRECTOR, GEO. PFEFFER—Florence Pipe Foundry & Machine Co., Florence, N. J.

DIRECTOR, E. P. WINTERS—Sloss Sheffield Iron & Steel Co., Birmingham, Ala.

HONORARY DIRECTOR, E. FRIEDLAENDER—Pittsburgh, Pa.

JOHN F. KELLY, Managing Director—Empire Building, Pittsburgh, Pa.

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy 50c

COMING MEETINGS ... AND PAPERS ...

PHILADELPHIA SECTION

NORMAN C. BYE, Chairman — L. O. MORROW, Secretary

SATURDAY, DECEMBER 7, 1929

"High Frequency Melting Furnaces," by Mr. Dudley Wilcox, Ajax Electrothermic Corporation, Trenton, N. J.
"Electrical Apparatus for the Coreless Induction Furnace," by Mr. N. R. Stansel, General Electric Co., Schenectady, N. Y.

Dinner 6:00 P. M. — Meeting 7:30 P. M.

All meetings held at Engineers' Club, Spruce Street, Philadelphia, Pa.

CLEVELAND SECTION

A. L. REICHERT, Chairman — J. E. WOOD, Secretary

FRIDAY, NOVEMBER 22, 1929

"Carbon Brush Standardization," by Mr. W. C. Kalb, National Carbon Co., Cleveland, Ohio.

Dinner 6:30 P. M. — Meeting 8:00 P. M.

Meeting will be held at the National Carbon Company's plant, West 117th Street and Madison Ave., Cleveland, Ohio.

CHICAGO SECTION

FRIDAY, NOVEMBER 22, 1929

"Internal Combustion Type Locomotive for Steel Plants," by Mr. D. C. Hershberger, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Dinner 6:30 P. M. — Meeting 8:00 P. M.

Meeting will be held at Electric Power Club, Chicago, Ill.

PITTSBURGH SECTION

WRAY DUDLEY, Chairman — R. J. HARRY, Vice Chairman

THURSDAY, JANUARY 16, 1930

Topical discussion covering developments in "Electric Overhead Traveling Cranes," by members of the A. I. & S. E. E. and leading crane and equipment manufacturers.

Meeting and discussion will be conducted by Mr. R. J. Harry, Assistant Electrical Engineer, Carnegie Steel Co., Homestead Works, Munhall, Pa.

THURSDAY, FEBRUARY 20, 1930

Topical discussion covering "Methods and Processes to Determine Rolling Mill Bearing Pressures," by members of the A. I. & E. E., Anti-Friction Bearing Manufacturers and Mill Builders.

Meetings will be held in the William Penn Hotel, Pittsburgh, Pa. Both meetings afternoon and evening session. Dinner 6:30 P. M.

Teck. 50

EDITORIAL

To the Iron and Steel Industry—

To the Crane Builders—

To the Membership of the A. I. & S. E. E.—

To the Managing Directors of Safety and Welfare Depts.

The A. I. & S. E. E. contemplate a revision of their Electric Overhead Traveling Crane Specifications and is submitting a questionnaire with the idea of obtaining an expression from the entire membership of the A. I. & S. E. E. and all other interested parties.

The answers that are submitted will form the basis of the proposed revision of the Crane Specifications.

This questionnaire has been compiled by a Special Committee headed by Mr. R. J. Harry of the Homestead Works of the Carnegie Steel Company.

You are invited to submit your answers to this questionnaire at once to—

Mr. R. J. Harry,
Special Committee on Cranes,
Carnegie Steel Company,
Munhall, Penna.

We are classifying the crane into four major divisions as follows:

BRIDGE—TROLLEY—ELECTRICAL EQUIPMENT—GENERAL

BRIDGE

1. Should crane girders be welded or riveted?
2. Should I beams with aux. girders be used for crane bridges where load and span permit?
3. How should rails be fastened to the girder (welded or bolted)?
4. What type of end truck do you prefer—cast, welded steel or structural steel riveted?
5. Does the use of heat treated track wheels justify the extra cost?
6. Which do you prefer, heat treated gears and press fits or the untreated gears with shrink fits?
7. What type of track wheel bearings do you prefer, bronze, roller or ball?
8. Where brass bearings are used for bridge axles, do you prefer grease or oil lubrication?
9. Do you favor the use of bridge motors without axle bearings equipped with flexible couplings and gear reduction in oil tight gear boxes, or motors with standard back axle construction?
10. Many types of floors are being used in crane cabs. What type of floor do you recommend?
11. Do you find that crane operators object to the use of wire reinforced glass in crane cabs?
12. Do you favor installing magnetic control in a separate cab or locating it on the footwalk?
13. Do you prefer single motor or two motor drive for bridge motion?
14. Should cranes be equipped with spring bumpers or solid bumpers?
15. Do you install shunt brakes on bridges of cranes and charging machines, where the operator travels with the trolley, to prevent accident in case of failure of power while crane is in motion?
16. Should platforms be installed under end of girders to facilitate changing track wheels?
17. Do you specify that safe means should be provided to get on crane from crane runway?
18. What warning signal do you find the most effective, Gong, Horn or Continuous bell alarm connected to line shaft?
19. Do you use sanders for bridge track wheels? If so, do you prefer electrically or manually operated type?
20. Should main contact rails be located on columns above the crane or should they be attached to the runway girders under the crane?
21. Should trolley contact rails be located between the crane girders or on the crane footwalk?
22. Is it good practice to weld girders and gusset plates to end trucks on cranes already installed?

TROLLEY

23. What type of trolley frame do you prefer, one-piece casting, one-piece welded frame, cast trucks with structural connections, or riveted structural frame?
24. What type of bearings do you prefer, brass, roller or ball?
25. Where anti-friction bearings are used, how often are they lubricated?
26. Where drums are keyed to drum shaft, do you use self-aligning bearings?
27. Do you find that a reverse bend effects the life of the hoisting rope?
28. Have you found the use of safety ropes on hot metal handling cranes justifiable?
29. Should equalizing sheaves have a diameter less than 30 times the diameter of the rope?
30. Should crane limit switches be operated by the hoisting mechanism or should they be actuated by the hook block when it reaches a predetermined height?
31. Should all crane limit switches provide dynamic braking and automatic reset for lowering?
32. Have you experienced any trouble with limit switch failure where it was necessary to run the cable supporting the counterweight, over sheave wheels?
33. What type of magnet wire take-up reel are you specifying on your cranes—spring operated, torque motor operated, or gear or chain operated drums driven from the hoisting mechanism?
34. A great many trolleys are being built using worm drive on the hoist and trolley motion. Do you prefer this type, spur gear, or herringbone gear type?
35. On hot metal handling cranes it is customary to install a brake on the motor, another brake on the motor axle shaft and supplement both of these with dynamic braking. Are there any crane applications where the brake on the motor axle can be eliminated?
36. On the hoist and trolley do you prefer heat treated gears and press fits or untreated gears with shrink fits?
37. Do you prefer oil lubrication, grease cup lubrication or high pressure grease lubrication?
38. Are you specifying oil tight gear cases or safety gear cases which afford chiefly a safety covering over the gears?
39. Have welded gear cases proven satisfactory where used?
40. Do you prefer cast steel drums or cast iron drums?
41. Are mechanical brakes now obsolete for mill type cranes?
42. Do you find brakes to be necessary on trolleys equipped with anti-friction bearings?
43. Should sanders be installed on crane trolleys?
44. Should crane trolleys be equipped with spring bumpers?

ELECTRICAL EQUIPMENT

45. Do you prefer motors equipped with sleeve bearings, ball bearings, or roller bearings?
46. Is it your practice to replace a defective motor or make the necessary repairs on the crane?
47. What type of control do you prefer for cranes—magnetic exclusively, part magnetic and part manual, or manual exclusively?
48. Should controllers have spring return handles to protect men and machinery in case craneman should be gassed, faint or otherwise incapacitated?
49. Do you prefer crane protective panels or should each control be equipped with its own protective apparatus?
50. Should cranes be equipped with a main line safety switch or enclosed circuit breaker?
51. Do you favor the exclusive use of unbreakable resistance for crane service?
52. Should sleeve bearings on motor axles be grease lubricated or oil ring lubricated?
53. Should motors be keyed to base plates?
54. What formula do you use to determine the horsepower required for hoist, bridge and trolley motors when crane is equipped with sleeve bearings? Also formula when crane is equipped with anti-frictian bearings?

GENERAL

55. Should all bolts on cranes be equipped with cotter pins?
56. Do you install repair trolleys over crane runways to facilitate repairs with minimum labor and loss of time?
57. What should be the minimum clearance between end of crane and building column?
58. What should be the minimum clearance between highest point of crane and bottom of roof truss?
59. What kind of grease or oil do you find best suited for worm gears? For spur gears? For herringbone gears?
60. Has lubrication from a central location proven satisfactory where installed on cranes?
61. Should crane operators be given a physical examination periodically? If so, how many times a year and how thoroughly should they be examined?

INDEX TO ADVERTISERS

A

Alliance Machine Co. 640
Allis-Chalmers Mfg. Company 675
Aluminum Company of America 619
American Gas Association 676
Appleton Electric Company 685

B

Baker-Raulang Co. 653
Bartlett Hayward Company 671
Benjamin Electric Mfg. Co. 637
Blaw-Knox Company 672
E. W. Bliss Co. 635
Bull Dog Electric Products Co. 633

C

Chapman-Stein Company 614-615
Clark Controller Co. 677
Cleveland Crane & Engineering Co. 668
Colt's Patent Fire Arms Mfg. Co. 682
Combustion Engineering Corporation 606-634
Crocker-Wheeler Electric Mfg. Co. 679
Crouse-Hinds Company 664
Cutler Hammer, Inc. 628-659-666-681

D

DeLaval Steam Turbine Co. 640-645
Delta Star Electric Co. 641
M. H. Detrick Co. 686
Doubleday Hill Electric Company 649
Duquesne Light Co. 662

E

Economy Fuse & Mfg. Company 656
Electric Controller & Mfg. Co. 617-657
Electric Machinery Mfg. Company 665
Electric Service Supplies Co. 648
Electrical Engineers Equip. Co. 641
Electro Dynamic Co. 618

F

Farrel-Birmingham Co., Inc. 636
Franklin Electric & Construction Co. 649

G

General Electric Company 630-631-670-Cover 4
Graybar Electric Company 642

H

Harnischfeger Corporation 663
Holophane Company, Inc. 616
Hyatt Roller Bearing Company 607

I

Ideal Commutator Dresser Co. 647
International Nickel Company, Inc. 609
Iron City Electric Co. 650
ITE Circuit Breaker Company Cover 3
Ivanhoe Division of The Miller Company 610

J

Jefferson Electric Company 678

K

Keystone Lubricating Co. 623

L

Lapp Insulator Co., Inc. 627
LeCarbonne Company 642

M

Martindale Electric Company 651
Moloney Electric Company 650
Monitor Controller Co. 632
Morgan Construction Company 620-621
Morgan Engineering Company 683
Morganite Brush Co. 643

N

National Air Filter Company 655
National Carbon Company, Inc. 673
New Departure Manufacturing Co. 611
Nichols Lintern Co. 660
Norma-Hoffmann Bearings Corporation 669

O

Ohio Electric & Controller Co. 622
Okonite Company 626

P

Penn-Union Electric Corporation 648

R

Railway and Industrial Engineering Co. 652
Reed Air Filter Co. Front Cover
Reliance Electric and Engineering Company 612
Rockbestos Products Corporation 658
Roller-Smith Company 644
Rowan Controller Co. 643

S

Shepard Niles Crane & Hoist Corporation 674
SKF Industries, Inc. 625
Standard Underground Cable Company 629
Stackpole Carbon Company 624

T

Thompson Electric Company 644
Timken Roller Bearing Company 680
Tool Steel Gear & Pinion Company 645
Trumbull Electric Mfg. Company 608
Trico Fuse Mfg. Co. 638

U

R. E. Uptegraff Mfg. Co. 647
Union Electric Mfg. Co. 646

V

V. V. Fittings Company 654

W

Westinghouse Electric & Manufacturing Co. 661-667-684 Cover 2
Weston Electrical Instrument Corp. 646
George D. Whitcomb Company 613
Edwin L. Wiegand Company 639

Modern Blast Furnace Theory and Practice°

By RALPH H. SWEETSER* and S. P. KINNEY†

Synopsis— This paper calls attention to the paucity of knowledge of the fundamentals of ferrous metallurgy and to the recent effective investigations of the phenomena of the interior of the iron blast-furnace. The adoption of a measure of performance of a blast-furnace has indirectly resulted, during the past ten years, in almost doubling the daily output of pig iron in stacks of given height and bosh diameter. This knowledge of how to increase production has led to a still greater need of knowing the details of the multiplicity of the chemical and physical reactions between hot air and incandescent coke and the iron-bearing materials and fluxes. The second part of this paper describes some of these investigations and gives a hint of the importance of the data obtained.

The most valuable by-product of the blast-furnace, the waste gas, is now receiving the attention that it deserves. Greatest in volume and by weight, of all the products, and by-products of the blast-furnace, yet in many cases its importance has been overlooked. New uses for blast-furnace gas are now being developed in this country, and the first coke ovens underfired by blast-furnace gas are now working satisfactorily.

Progress in preventing waste in the steel industry has made the use of hot metal direct from the blast-furnace to the steel plant the almost universal practice. This past year has seen the introduction of the movement of hot metal for longer distances than ever before attempted.

The twelve-hour day and the twenty-four "long shift" at blast-furnaces have been abolished, and the three-shift day has been adopted at all up-to-date blast-furnace plants. Machinery has lifted the burden of the hot, heavy drudgery of the hand-filled furnace and has made the pig bed obsolete. Machinery has even given a new meaning to the name of "pig iron" and we now speak of "hot metal" and "iron in pigs," rather than of sand-cast and chill-cast pig iron.

Merchant blast-furnaces are now making about one-fourth of the total annual production of pig iron in the United States. The specifications for chemical analysis and physical structure of merchant pig iron are becoming more exacting, and the foundrymen are demanding such evenness of quality and analysis, that it is impossible to operate a merchant furnace without having the accessories and recording and controlling devices for maintaining smooth and continuous operation.

Not only must ore, coke and limestone going into the furnace be regular and of known analysis, but the manipulation of the furnace and the materials must be under control so as to produce the right "personality" in the pig iron.

The movements of the downward column of solid materials and the upward movements of the tremendous volume of hot gases inside the blast-furnaces are described and pictured by Mr. S. P. Kinney in the second part of his paper.

The remarkable advance in blast-furnace practice in the past ten years in the United States has been made without any great change in design and without any great invention in equipment or in accessories.

The steady increase in output per blast-furnace stack has been accomplished with diminishing conversion costs and with increased safety in spite of the almost universal adoption of the 8-hour day for all continuous jobs and an increased hourly and daily wage. A part of the progress has been due to improvements in apparatus tending to more uniform operation, and also there have been a few changes in the dimensions of the interior of the blast-furnace which might be considered as refinements of the practice of ten years ago, even including the further enlargement of hearth diameter which had reached the 20 ft. line as far back as 1918.

But the greatest advances in blast-furnace practice have been due to causes other than mechanical, and have been brought about more by changes in our attitude of mind than by changes in design and equipment.

We can hardly say that new theories have been advanced to replace old theories of blast-furnace operation, but rather can we say that we now have a clearer conception of what actually takes place inside the blast-furnace, and we also know more as to the practice that will permit the greatest quantity of iron-bearing raw materials to be smelted in a furnace of a certain size in twenty-four hours' time.

The state of the art of iron smelting twenty years ago was quite truthfully expressed by an English author in a book published in London in 1909 ("Blast-Furnace Practice," by J. James Morgan, F.I.C., F.C.S.) who said, "Although the production of pig iron is very simple in principle, the changes, chemical and physical, which the material undergoes in the blast-furnace are many and complicated, and not altogether understood. Many can only be guessed at, while even those which are known may be accompanied by others of which nothing is known." Only ten years ago, the late J. E. Johnson, Jr.,* said "The authors of the (scienctific papers and some books) have attempted to solve the riddles which the blast-furnace furnishes, but, in my judgment, none of them succeeded in proposing any theory, which fits or explains the important facts."

The progress in the art of operating iron blast-furnaces during the ten years immediately preceding the last year of the World War was described with

*The American Rolling Mill Co., Columbus, O.
†H. A. Brassert & Co., Chicago, Ill.
°Presented before World's Power Conference, Nov., Tokio, Japan.

*The Principles, Operation and Products of the Blast-Furnace, J. E. Johnson, Jr., New York, 1918.

detail and clarity by James G. West, Jr., in his paper, "The Principal Changes in Blast-Furnace Lines During the Past Ten Years," presented at the fourteenth general meeting of the American Iron and Steel Institute in New York, May 31, 1918. Mr. West began his paper with these words, "Any one making a careful study of the results achieved in the modern blast-furnace plant, would find it very difficult to assign attainments to any one particular line of designs, control, or operation." Mr. West then classified the lines of procedure to be observed in order to reach the desired point of "efficiency, production and smoothness of operations, under four general heads, as follows:

1st—Perfect knowledge of the materials must be had beforehand, both physically and chemically, and these should have as much regularity as possible.

2nd—Proper design of apparatus.

3rd—The organization must be keyed up to the highest point of skill and fully educated in the program to be pursued and in the results desired. The modern blast furnace is no longer a man-one proposition in its regulation.

4th—The mechanical equipment must keep running with a smoothness that will not hold back any of the other developments."

These four general lines of procedure are as necessary today as in 1918, and satisfactory blast furnace practice cannot be attained if any one point should be neglected.

But even though we did know the character and the analysis of our raw materials, and even though we did have the proper design of furnace lines and apparatus, and even though our whole organization had skill and enthusiasm, and even though the mechanical equipment kept on running without shutdowns, yet, in spite of fulfilling all these requirements, still there was lacking a most important factor that has since been recognized and provided.

Up to the year 1918, there was no rule for determining the capacity, expressed in tons of pig iron per 24 hours, of a blast furnace of given dimensions and using ore, coke and limestone of known analysis. We wanted "good lines" in our furnaces, and we demanded regularity in our materials, but we did not know just how much pig iron we should demand from our blast-furnaces after we had attained satisfactory lines and dimensions and were provided with acceptable materials. Dr. B. D. Saklatwalla very clearly expressed this lack of knowledge in his address before the Society of Chemical Industry, New York City, when he was presented with the Grasselli Medal Award, December 5, 1924. In speaking on the subject of "Fundamentalism in Ferrous Metallurgy," he said, in part, "complexity may be indicative of lack of progress, especially of the lack of clear understanding of the basic fundamentals of the art or science. The science of ferrous metallurgy seems to be more or less in this category. * * * There is no doubt in the mind of any conscientious scientist or technologist working in the field of ferrous metallurgy that he is hampered by the lack of explanation and data regarding the fundamentals of his subject."

This "lack of explanation and data regarding the fundamentals" of the art of making pig iron brought about serious and far-reaching troubles, especially during the shortage of iron and steel during the last years of the World War, and again during the period of changing from the two 12-hour shifts to the three 8-hour shifts for blast-furnace men. At that time we did not know what was the right tonnage for a blast-furnace, neither did we know what was the right day's work for a blast-furnace man. The solution of these two problems is a part of the progress in blast furnace practice during the past decade.

Blast Furnace Capacity

Previous to the World War, there was no generally accepted rule for measuring the capacity, expressed in tons of pig iron produced per day of twenty-four hours, of a blast-furnace of given dimensions. The lack of such a rule was painfully apparent during the hectic months of utmost iron and steel production in 1917 and 1918. The work of formulating such a rule was assigned to a committee of the Southern Ohio Pig Iron & Coke Association; the report of this committee was approved in October 1920.

The rule adopted for determining the tonnage capacity, or rating, of blast-furnaces is as follows:

"Regardless of grade of pig iron produced blast furnaces of modern construction should burn about the same amount of fuel daily under same operating conditions. For each grade of pig iron the tonnage which can be produced will depend upon the quality of fuel used, yield of ore mixture and blast temperature. The tonnage of coke which can be burnt in a unit of time has a certain ratio to the working volume of the furnace.

"From figures prepared on a number of different size furnaces, it has been found that with good practice 60# of coke can be burnt each 24 hours per cu. ft. working volume. The working volume is taken as volume from center line of tuyeres to two feet below bell closed.

"Therefore, the capacity of a blast-furnace must be expressed in terms of pounds of coke which can be burnt per day. And in order to cover variations which exist from time to time in operation, it is necessary to adopt a base coke, a base theoretical yield ore mixture and a base hot blast temperature and then make allowance for variations as encountered."

The analysis of the "base" coke referred to is as follows:

Fixed Carbon	89%	
Sulphur	1%	(maximum)
Ash	9–10%	
Volatile	1– 2%	

The structure of the "base" coke is tough, but not dense or fragile and free from breeze.

One well-known blast-furnace man in the Pittsburgh District objected to such a high rating for blast-furnaces, and gave as his reason—"There is hardly any big furnace today that would not be making six hundred tons per twenty-four hours, with this as a basis." This same man has recently

reached a daily average of 1,000 tons of pig iron per day in a furnace of less height but greater diameters at hearth and bosh, than was in vogue in the Pittsburgh District when 500-600 tons per day was the usual practice.

The Cleaning of Blast Furnace Gas

The necessity of removing the fluedust from blast furnace gas, especially in cases where high percentages of fine ores were used, brought about many devices for dry-cleaning and wet-washing of the waste gases before being burned in the hot-blast stoves and boilers. Each step in the advance in the art of hot blast control brought about improvements in the cleaning and the super-cleaning of blast-furnace gas. Here again the blast furnace man was "hampered by the lack of explanation and data regarding the fundamentals." Not only was it necessary to remove the dust particles from the gas, but it was learned that the water vapor and fumes must be condensed by lowering the temperature of the cleaned gases in order to obtain satisfactory combustion. Thermostatic control of pressure burners demanded a gas clean in every respect, so that the valves and burners would not become fouled with sludge or with moisture.

The greater the improvement in hot blast stoves and burners, the greater the amount of surplus blast furnace gas that becomes available for other purposes. The first need for the surplus gas is power to operate the blast-furnace itself. Even now there are many blast-furnace operators who clean the gas for the stoves very thoroughly, but are content with only a partial cleaning of the gas going to the boilers. The tendency, however, in the best managed plants is to recognize the economy of cleaner gas for the boilers. A thorough cleaning of all the waste gas saves labor and repairs at the boilers as well as at the hot blast stoves, besides allowing a greater recovery of fine fluedust for the sintering plant.

Although there are several gas engine power plants at American blast-furnaces, the more usual method is to use the gas for raising steam for the engines; the tendency is more towards turbo blowers than towards more gas engines.

The use of blast-furnace gas for underfiring by-product coke ovens is the latest development in the demand for cleaner gas in the United States. Not until October 1928, was this new use for blast-furnace gas actually put into operation in this country, though it had been successfully used in Germany for several years. The By-Products Coke Corporation of Chicago is now successfully using cleaned blast-furnace gas for underfiring two batteries of Becker cross regenerative type of Koppers coke ovens.

Probably the next use for blast-furnace gas in America will be for open-hearth steel furnaces. Although a mixture of blast-furnace gas with coke oven gas has already been used in Germany for this purpose, this practice has not yet been adopted in America.

Boynton* says, "The reduction in operating expense possible through the proper application of washed blast-furnace gas remains the most important single unrealized means of reducing the cost of American Steel. * * * Blast furnace gas has a nominal heat value of approximately $1.90 per ton of pig iron, based on an average price of $3.75 for coal, including cost of firing."

*Arthur J. Boynton, vice president, H. A. Brassert & Co., Chicago, "Cleaning Blast-Furnace Gas," American Institute of Mining and Metallurgical Engineers, Technical Publication No. 125, September 1928, and Iron and Steel Technology in 1928, Iron & Steel Division.

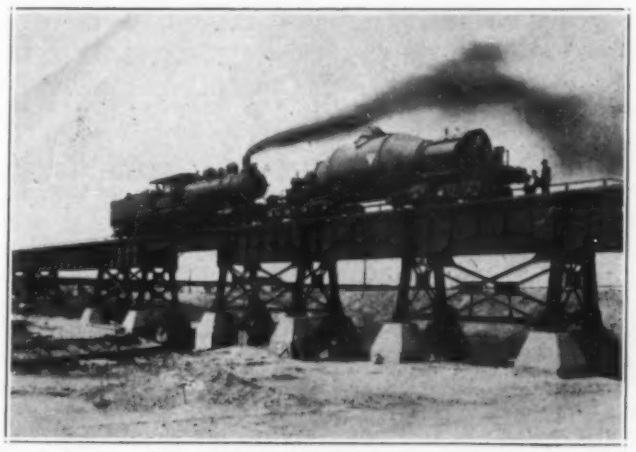
Movement of Hot Metal

The movement of hot metal from the blast-furnace to the steel plant plant converters and open-hearth furnaces has been a standard practice in America for many years, and there has been a steady advance in the size of the ladles used and the length of haul.

About sixty-five per cent of all the pig iron now being made in the United States is used as direct metal in the Open Hearth furnaces and Bessemer converters of the steel plants with which the blast-furnaces are connected. In most cases, the movement of the molten iron is for a short distance, and in at least one case there is no movement of the ladles by railroad.

The greatest achievement in this practice occurred in June, 1928, when the first ladle of hot metal from the blast-furnace of the Hamilton Coke & Iron Company at Hamilton, Ohio, was transported over the tracks of the Baltimore & Ohio Railroad a distance of ten miles to the Open-Hearth furnaces of The American Rolling Mill Co., at Middletown, Ohio. The cast of iron was run from the blast-furnace into a mixer ladle holding 150 tons of molten iron, mounted on two sets of eight-wheel trucks. The ladle is a Pugh type of the largest size

Mixer Ladle and Car



Mixer Ladle, Tracks and Trestle

yet constructed. A railroad bridge of special construction was built across the Miami River near Hamilton, designed to carry a concentrated load of 325 tons on the 16 wheels of the ladle car. It requires a fleet of three of these unique ladles, which "look like land submarines," to transport the molten iron across country from the blast-furnace plant to the Open-Hearth plant. The photographs of these ladles shows the heavy construction of the mixer ladle, and the railroad tracks and trestles.

Adoption of the Three-Shift Day

The almost Universal adoption of the three-shift day at blast-furnaces in the United States was accomplished during the past decade, after much intensive study of the problem and with but few labor disturbances. The use of machinery for nearly every operation around the blast-furnace made it possible for a man to do more in eight hours than he could do in twelve hours by the old hand methods.

It did not require 50% more men for three shifts than for two shifts in 24 hours, because the idle time between casts was practically eliminated, and machinery lifted off the men the heavy burden of hand labor. The net results of the change have been a greater output per man, a much higher rate of wages per hour, reduction in labor turn-over, practically the same labor cost per ton of pig iron and practically the same monthly earnings at eight hours per day as formerly at twelve hours per day.

The Department of Labor is making an exhaustive study of this great increase of output and of earnings per man-day. One direct result has been that the men may continue in blast-furnace work as they grow older without being forced to give up their jobs on account of the long hours and heavy manual labor. The position of iron-carrier is now obsolete and even the work of opening and closing the iron notch and the cinder notch is done with machinery.

As for safety around blast-furnaces, there is less danger of accidental injury than there is on a farm. The intensive safety campaigns have made our blast-furnace plants safer than the streets and farms. Some blast-furnace plants have operated throughout a whole year without any lost-time accidents.

Merchant Blast Furnaces

The trend of the proportion of merchant iron produced in the United States has slowly and irregularly decreased from about one-third of the total production twenty years ago to about one-fourth at the present time. Three-fourths of the pig iron produced in this country is used by the makers in their own steel plants, and over 85 per cent of this iron is used in the molten state direct from the blast furnaces.

The predominance of steel-plant blast-furnaces has brought about the practice of selling surplus pig iron from these furnaces to the users of merchant pig iron. Usually the price of such iron is lower than the price at which the strictly merchant furnace can sell, and in many cases the iron from the big steel plant blast-furnaces answers the purposes of the foundryman as well as the iron from the merchant furnaces.

Obsolescence of many of the blast-furnaces that struggled through the World War has resulted in the demolition of about 100 blast-furnace stacks, of which about 80 were merchant blast-furnaces. It is now the general opinion that no merchant blast-furnace stack can successfully operate unless it is directly connected with a by-product coke oven plant. Very few new merchant iron furnaces have been built during this period, and these few were built at stragetic points where the consuming market required additional pig iron, and in all cases, these new blast-furnaces have been built on navigable waters, with the exception of the merchant iron furnace built in Prove, Utah, in 1924.

Within the past three years, there has been much agitation of the problems of correct analysis of pig iron for specific uses. The increase in the number of big grey iron foundries and malleable iron foundries has resulted in very definite specifications for the pig iron to be melted in cupolas. Several round table conferences of blast-furnace men and foundrymen have been sponsored by the American Institute of Mining and Metallurgical Engineers and by the American Foundrymens' Association. These discussions have brought about the much desired investigation of knowing more exactly the conditions under which the pig iron was produced in the blast furnace and following the iron produced through the foundry and into the machined castings. The most notable investigation of this kind has just been carried out by the General Motors Corporation and reported in detail by A. L. Boegehold, Metallurgist of the General Motors Corporation. This paper was presented at the April, 1929, meeting of the American Foundrymens' Association. According to Mr. Boergehold, "The investigation discussed in this paper strengthens belief in the idea that physical character of pig iron is greatly influenced by variations in blast-furnace operation and that two pig irons may have almost identical chemical composition with regards carbon, silicon, manganese, phosphorous and sulphur but still be as far apart as the poles in physical properties.

"Also it is quite definitely demonstrated that the physical characteristic of pig irons persist during remelting in the cupola and greatly influence the physical properties of the cast iron made therefrom.

The data collected and tests conducted show that two things are responsible for a number of variations in blast-furnace operation and resultant properties of pig iron. These two things are quality or combustibility of coke and amount of water in the blast. The influence of these variables is just as important in the cupola as in the blast-furnace. Just as long as these factors are allowed to vary as they now do, we can expect wide variation in the qualities of pig iron and of the cast iron made from it."

This paper further states, "The thing every foundryman is interested in, I believe, is to obtain pig iron which always behaves the same. What he wants is uniformity of raw materials."

Some of the users of foundry pig iron are demanding the percentage of silicon to be within one-tenth of one per cent of the silicon specified in the order and instead of asking for sulphur content of a maximum of .050%, they are demanding a maximum of .040% and even .035%. In the malleable iron, the content of chromium must be guaranteed to be under .015%, and the specifications of phos-

phorus contents are so close that the phosphorus in some cases must be over .15% and under .18%.

With such close specifications as to the chemical composition and also as to the "personality" of the pig iron which includes investigation as to the prenatal conditions of the iron within the hearth of the furnace, it is evident that there will be a greater demand for merchant pig iron made under conditions which will insure the delivery to the foundryman of iron strictly within his own exacting specifications.

Scientific Investigations of the Blast Furnace

It is my opinion that the most important investigations of the physical and chemical conditions in the interior of the blast-furnace since the time of Sir Loothian Bell have been performed by a man in the United States Bureau of Mines and the most significant facts brought out were the results of the investigations of Mr. S. P. Kinney, lately of the U. S. Bureau of Mines, and now connected with H. A. Brassert & Company of Chicago. Mr. Kinney will tell of these investigations in his own words:

Physical and Chemical Conditions in the Interior of the Blast Furnace (1)

By S. P. KINNEY (2)

Synopsis

This paper points out simply, without giving detailed experimental results, some of the irregularities existing in blast-furnace practice. It has been found by the United States Bureau of Mines that the flow of stock in the furnace is toward the tuyeres, and the descent is not uniform throughout the shaft. The current method of charging causes a difference in density and porosity throughout the column, and this, combined with the irregularities in stock flow, result in gas flow which is not uniform. These factors, coupled with incorrect distribution, result in a stock column which is too porous or open at the center or at the inwall; both of these factors result in the emission of gas of low carbon dioxide content at the stockline. Where the temperature is high at the inwall, the effect on wearing plates and lining is destructive. A study of the gas composition, temperatures, pressure and velocity measured from the inwall to the center of the furnace on a series of planes between the tuyere level and the stockline indicates ways and means of improving the practice.

EXTERIOR AND INTERIOR FACTORS IN FURNACE OPERATION

Mechanical Improvements

The operator of the iron blast furnace is ever alert to attain uniformity of working. Great strides have been made in this direction by careful preparation of materials, improved charging devices, uniformity of blast temperature, and by many other innovations, each of which has brought nearer a more uniform practice and a larger unit production. Little attention, however, has been paid to the interior of the furnace where many non-uniform conditions exist. It is the purpose of this paper to show what these conditions are, as revealed by past and current investigations of the U. S. Bureau of Mines.

Combustion of Coke in the Furnace

In 1919 the Bureau of Mines began making field studies of the interior of the Iron blast furnace (3). Considerable effort was spent in trying to relate some of the physical properties of coke to the operation of the furnace, and the interior of the hearth was surveyed to determine whether cokes of widely varying physical properties showed differences in character in the combustion zone. The hearths of 15 blast furnaces using cokes differing widely in physical characteristics were sampled with water-cooled gas-sampling tubes. It was shown that the combustion of the coke by the blast is complete 32 to 40 inches from the hose of the tuyere. Little difference was found in the character of the combustion zones in the furnaces, and it is probable that the large differences observed in blast-furnace practice with different cokes are due to other factors than the relative combustibility of the cokes at the tuyere zone. Figure 1 shows the average analysis of the gas obtained at the tuyere plane of 10 blast-furnaces. These results have been discussed at length elsewhere (4) but the conclusions and fig-

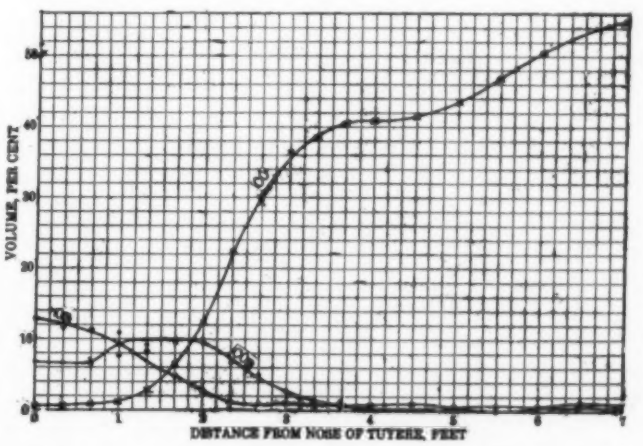


Fig. 1—Average analysis of gases at tuyere plane of ten blast furnaces.

(1) Published by permission of the Director, U. S. Bureau of Mines (not subject to copyright).

(2) Former Metallurgist U. S. Bureau of Mines.

(3) Perrott, G. St. J., and Kinney, S. P., "Combustion of Coke in the Blast-Furnace Hearth": Trans. Am. Inst. Min. & Met. Eng., vol. 69, 1923, pp. 543-584.

(4) See reference 3.

ures are given for the purpose of bringing out several facts in regard to gas and stock flow.

As previously pointed out, uniformity in materials, charging and blast temperature are very desirable features in furnace operation. Examination of Figure 1 indicates clearly that combustion is probably taking place in a spherical zone at the nose of each tuyere. These zones are limited in length, and are small when compared with the remaining volume of the furnace.

Most important is the fact that, as the zone is of constant length, the distance between opposite zones increases with each increase in hearth diameter. The effect of this is two-fold: First, as the combustion of the coke creates a void at the tuyere zone, the flow of the stock is toward this combustion zone; and second, as the gases from a point near the end of this zone to the center of the furnace at the tuyere level contain 40 to 55 per cent of carbon monoxide, it is logical to believe that there is non-uniformity of gas flow. The results of gas sampling at a point 27 inches, 19¼ ft. above the tuyeres, and at other points and at other places have also been discussed elsewhere. ([5]) It was shown that there is a certain non-uniformity of gas flow in the hearth and bosh of the furnace. With this in mind, an investigation of the gas composition of a series of places between the tuyere level and the stockline was undertaken in other furnaces.

Uniformity of Gas and Stock Flow

A better working condition would be attained, it is believed, if the flow of the stock downward and the gas upward were uniform. If the stock flowed uniformly downward throughout the cross-section of the furnace, its treatment in the approach to the hearth should be uniform, provided that the gas, in turn, flowed uniformly upward. The case is of course ideal, and would mean extremely good contact between gas and solid. Under such conditions the process would be accelerated. There would be no chance for any of the gas made from expensive coke in the hearth and bosh of the furnace to find its way to the top of the stock column without doing work of reduction.

If it be assumed that uniformity of stock and gas flow is an ideal attainment, one would expect that with these conditions, gas composition, temperature, static pressure, velocity pressure, and in turn, the gas velocity across any place would be uniform from inwall to inwall. With uniformity in these factors one would find in the shaft of the furnace a uniformity of flow of materials downward.

Flow of Blast Furnace Stock

The Bureau of Mines pointed out from a laboratory study that the flow of stock in the blast-furnace is toward the tuyeres ([6]) Later field tests confirmed these results. ([7]) It is the writer's belief that uniformity of stock flow across any place parallel to the hearth cannot exist in the presence of the localized combustion zones whose effect must be transmitted to the stock column. Certainly it is correct to assume that at a point, say 6 inches above the top of the combustion zone, the effect of this transformation of carbon is reflected in the movement of stock. Is not this effect therefore transmitted to some point higher in the column? If so, how far is it transmitted to the top of the column, or is it transmitted laterally so that the resultant effect is a uniformity of stock flow to a point above the top of the bosh? With these and similar questions in mind the experiments to be described were attempted. The results seem to indicate that the flow of stock in the furnace is not uniform, but is toward the combustion zones, and that their effect is transmitted to the stockline.

Test Procedure

The rate of flow in the straight section at the top of a blast-furnace was measured by means of a cable to which was attached an iron rod 1-inch in diameter and 4 feet in length. The rod was lowered through a try-rod hole until the end just rested on the top of the stock. When the big bell of the furnace was lowered, the rod was caught by the incoming charge. The cable was then drawn tight, and the rate of movement of the cable was recorded against a stationary bench mark. In a number of trials two or three cables were employed at the same time at different sides of the furnace.

In order to compare rates of flow, an attempt was made to measure the rate through the center of the stock column. In this test a 1-inch double extra strong pipe was bent and clamped to the lip

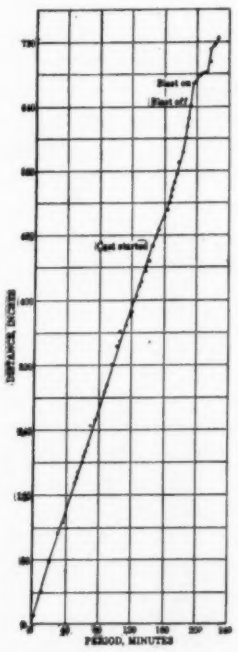


Fig. 2—Rate of flow of stock as measured through No. 2 try-pod hole (over cinder notch) of a 700 ton furnace.

(5) Kinney, S. P., Royster, P. H., Joseph, T. L., Iron Blast-Furnace Reactions; Tech. paper 391. 1927, 65 pp. Bureau of Mines.

(6) Royster, P. H., and Joseph, T. L. "The effect of coke combustibility on stock descent in the blast furnace." Trans. Am. Inst. Min. & Met. Eng., vol. 70, 1924, pp. 224-232.

(7) Kinney, S. P. "The blast-furnace Stock Column (based on a study of a 700-ton furnace); Tech. Paper, Bureau of Mines in press.

ring of the furnace. At the beginning of the test, the weight was placed in the stock at a point 42 inches below a 3-foot stockline at the center of the column. The cable was fed through the curved pipe, and the movement of the cable was recorded as the weight was carried down with the stock.

In determining rates of flow, the four try-rod holes in the lipring and at the top of the furnace were numbered I, II, III and IV over the cinder notch, iron notch, opposite the cinder notch and on the skip side, respectively.

Results of Stock Flow Tests

Figure 2 is typical of the results obtained in the measurement of the rate of descent of stock in the straight section at the top of a furnace reducing Lake Superior Ores and making basic iron. It is typical of the operation of this particular furnace, but not of all furnaces. One furnace tested in a similar manner indicated that the charge at the time of check descended in jerks, at 45-minute intervals; another furnace showed a stock descent by means of short intermittent slips, a few minutes apart.

As an example of the results obtained from these tests the values for the curve of figure 2 and other tests on the same furnace are summarized in Table 1.

In the seven tests listed in Table 1, it was found that the average rate of descent of the stock in the cylindrical portion of the furnace, at the stockline, on a vertical line 9 inches from the inwall, was 2.78 inches/minute.

Calculated Rate of Flow

From the rate of iron production and the volume of materials required for each unit of iron, the thickness of a charge in the cylindrical portion of the furnace at the stockline was determined. From these data, assuming that the rate of descent was uniform, it was calculated that the average rate of flow of the stock in this case should be 1.99 inches/minute. The calculations were made simultaneously with test No. 3, where the rate found by measurement was 3.16 inches/minute. The calculated rate in this case was 63 per cent of the actual rate at the point observed.

In brief, the results indicate clearly that the descent of the stock toward the tuyeres is not uniform and that the effect on stock flow of the localized combustion zones at the nose of the tuyeres is transmitted to the stockline of the furnace. If the stock flow toward the hearth is not naturally uniform, it is logical to assume that part of the materials charged are reaching the hearth faster than some other part, and that the materials are not all receiving the same gas contact.

Table 1. Summary of Stock Flow Tests

Test No.	Date 1926	Try Rod Hole No.	Try Rod Hole Place	Period Min.	Distance Inch	Rate Min. In.	Calculated Period 3-ft. Stockline to Tuyeres Min.	Hrs.	Min.
1	June 22	2	Iron Notch[a]	24	68	2.82	288	4	48
2	June 30	1	Cinder Notch[b]	169	403	2.40	340	5	40
3	July 6	2	Iron Notch	159[e]	503	3.16	258	4	18
4	July 6	1	Cinder Notch	148[e]	433	2.92	280	4	40
5	July 6	4	Back Notch[d]	145[e]	423	2.93	279	4	39
6	July 14	2	Cinder Notch	164	402	2.46	332	5	34
AVERAGE						2.78	296	4	54
7	July 14	2°	Cast°	165	349	2.10	388	6	29

a—over iron notch
b—over cinder notch
c—to start of cast
d—back of furnace
e—test made at center of stock column, reached by means of a curved pipe through try-rod hole No. 2.
f—68 feet, ¼ inch from 3-ft. stockline to tuyeres.
g—assuming rate is not affected by batter in inwall.

Examples of Gas Composition and Distribution In Various Blast Furnace Shafts

As already stated, if there is uniformity of stock flow downward and gas flow upward, the gas composition across any plane in the shaft of the furnace should be uniform. Figure 3 shows the analysis of the gas sampled from the inwall to the center of the furnace on a plane 3 feet below the top of the stock. This 300-ton furnace was producing foundry

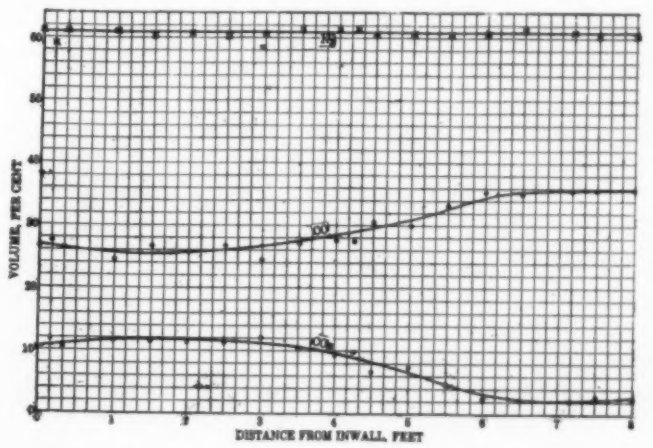


Fig. 3—Gas composition on plane three feet below the top of the stock.

iron from southern ores, nearly self-fluxing. The top gas contained approximately 9 per cent carbon dioxide. From the curve it may be seen that the furnace gas at a point 20 inches from the inwall contained 12 per cent carbon dioxide, and the gas in the vicinity of the center of the top of the shaft contained 2 to 4 per cent. As all of the gases go into the top gas, it follows that the lean gas was mixing with the rich gas to form the average top gas of 9 per cent carbon dioxide. Here again it might be pointed out that the reactions which produce this carbon dioxide are not being carried on uniformly; also, gases which have been produced from expensive coke are reaching the top of the stock column without having done any work of reduction.

Figure 4 is an example from another furnace. Here the samples were taken at the same depth below the top of the stock. In this case, the carbon dioxide in the top gas averaged approximately 13 per cent, which is considerably higher than that in the furnace previously mentioned. Here the maximum carbon dioxide content of the gas is approximately 19 per cent. The highest percentage of carbon dioxide is found in the center of the plane. At the wall it is low—approximately 4 per cent. Here the lean gas is finding its way to the top of the

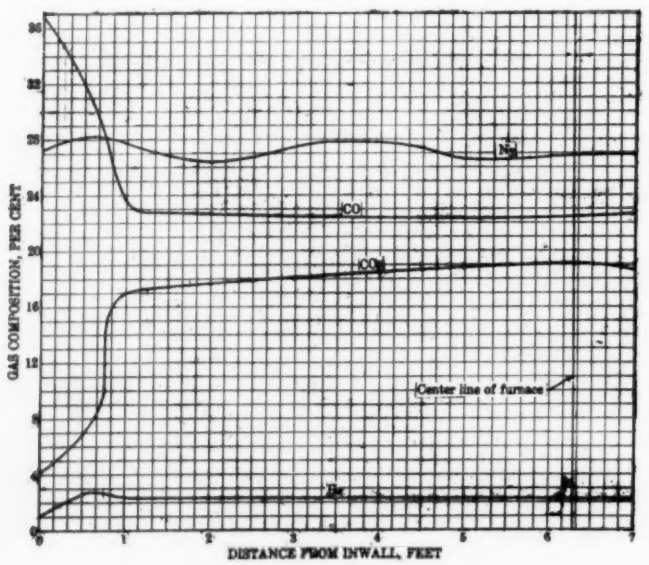


Fig. 4—Gas samples on a plane three feet below the top of the stock.

stock column by coming up near the wall, whereas in the first case, the lean gas was found near the center. Before passing to Figure 5, it should be pointed out that a maximum of 19 per cent carbon dioxide has been attained here, and the average of the gas between 1 and 7 feet from the inwall is approximately 18 per cent. It would indeed be desirable if this percentage could be maintained throughout the area of the plane. Table 2 gives the ratio of carbon monoxide to carbon dioxide (CO/CO_2) at various points between the inwall and the center of the furnace.

Table 2. CO/CO_2 ratio of gas from inwall to center of furnace on plane 3 feet below top of stock column.

Distance from Inwall, Feet	CO/CO_2 Ratio
0.0	9.7
0.5	4.5
1.0	1.35
2	1.34
3	1.33
4	1.22
5	1.23
6	1.23
7	1.25
Top Gas	2.00

CO/CO_2 ratio of a considerable portion of the gas is of the order of 1.2, whereas the top gas has a ratio of 2.0 Bell (8) points out that the ration could not be less than 2.0 in certain operation. The result here indicates that it is possible to attain ratios of the order of 1.0. Examination of the gas across a plane near the top of the stock indicates that a considerable portion contains CO/CO_2 ratios of the order of 1.2. The Bureau of Mines has obtained results from several furnaces which indicate a CO/CO_2 ratio of 1.4 in the top gas, and the indications are that it should be possible with better uniformity of stock and gas flow in the blast-furnace shaft—that is, proper gas-solid contact—to attain CO/CO_2 ratios of 1.0 in the top gas; such a ratio, if attained, will result in better fuel economy.

Temperatures In the Blast Furnace Stock Column

Methods have been developed by the Bureau of Mines for measuring temperatures from the inwall to the center of the furnace on any plane in the shaft. The temperature curve of Figure 5 should be read with Figure 4. The two curves indicate

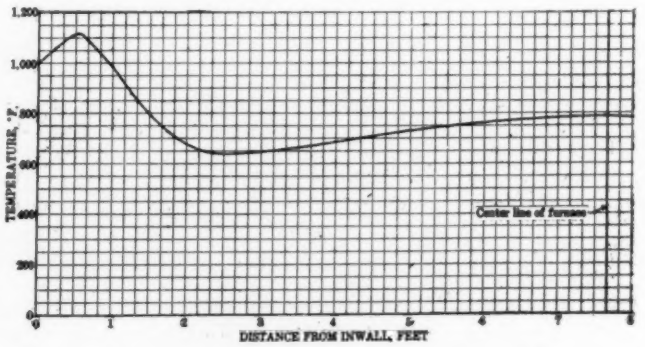


Fig. 5—Temperature from inwall to center of furnace, on a plane three feet below the top of the stock.

clearly that the gas at the inwall of the furnace is of high temperature and is low in carbon dioxide. Obviously, the distribution or the design of this furnace is such as will allow a good portion of the lean gas to escape without doing work of reduction.

Figure 6 shows the temperature taken from the inwall to the center of the furnace on a plane 3 feet below the top of the stock. In this case, the high temperature is at the center of the furnace. The gas of low carbon dioxide content is also at the center of this column. Here the lean gas was channeling up through the center of the column of stock.

(8) Bell. I. L., Chemical Phenomena of Iron Smelting, London 1872.

If the hot gas had come in contact with iron oxide, reduction would have taken place, the temperature of the gas would have been lowered, and the product

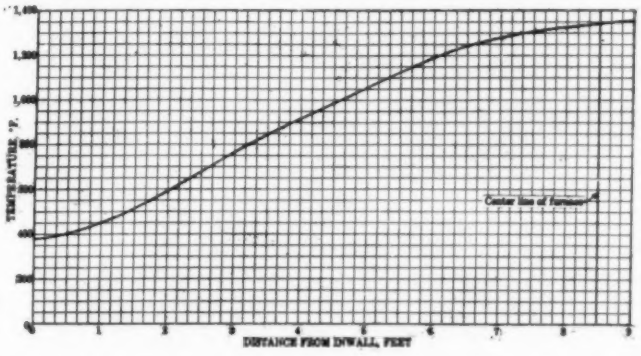


Fig. 6—Temperature from inwall to center of furnace, three feet below the stock line.

of the reduction, in the gaseous phase, would have been carbon dioxide. With the high carbon dioxide content, there would have resulted a lower coke consumption.

To this point it has been shown that the flow of stock in the furnace is not uniform, that the gas composition from inwall to center on any plane has considerable variation, and that the temperature on these planes is not uniform. The picture might be made more complete if the relative velocities of the gas passing up through the shaft were known.

The Bureau of Mines has developed means for measuring the static pressure, and the static and velocity pressure, from the inwall to the center of the furnace; from these observations the gas velocities may be calculated. Space limits description of the apparatus used and the detailed results from various planes of a number of blast-furnaces. Figure 7, however, shows an example of the velocity attained by the gas at a plane 3 feet under the stockline. The highest gas velocity in this case is at the center of the furnace, where a high temperature exists, similar to that shown in Figure 5, and where the gas contains little carbon dioxide, as is shown in Figure 3. In general, where high gas velocity exists there is also a high temperature, and also as the gas has had little chance to come in contact and react with iron oxide, gas containing small amounts of carbon dioxide will be found.

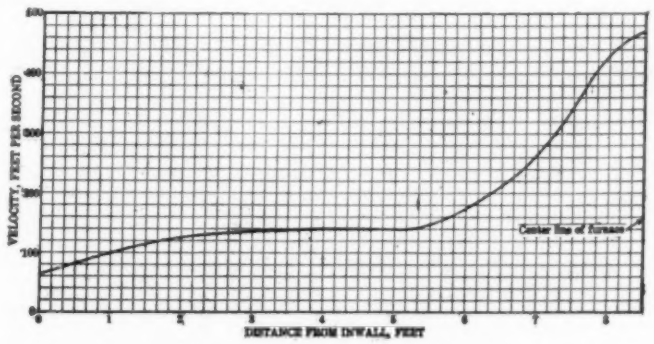


Fig. 7—Gas velocity of temperature and pressure of plane, three feet below the top of the stock column.

Distribution

With the use of the methods developed for taking gas samples, temperatures, pressures, and gas velocities, it is possible to obtain a concrete picture of the physical and chemical conditions existing in the shaft of the blast-furnace. For example, the methods lend themselves to the study of such important factors as stock line-bell ratio, and batter and distribution of materials at the stockline. Where the stock line-bell ratio is incorrect, a furnace that functions poorly will result. The question then arises—what change should be made in this ratio and to what extent should it be changed? A careful study of the gas composition, temperature, and velocity from the inwall to the center of the furnace will soon indicate whether the proper uniformity in these factors is being attained. If not, the results will indicate the direction, and possibly the degree, in which the corrective measure should be taken. After the change has been made, comparison of data will show just what result has been obtained.

The work should play an important part in the study of distribution of materials. For example—a furnace with a coarse charge may be discharging material from the big bell in such a manner as to place the fine material in the charge near the inwall and the coarse material near the center, thus giving a porous and open center. In an extreme case of this kind the gas velocity and temperature at the center will be high while the carbon dioxide content of the gas will be low; or the reverse of this condition may be found. A change in the rotation in which the materials are discharged from the big bell will frequently result in improving the condition; each condition has certain characteristics but should be studied individually.

Preparation of Raw Materials

The preparation of raw materials plays an important part in furnace operation. It is the writer's believe that the physical properties of the materials charged are as important as the chemical properties. The results shown in Figure 3, where the carbon dioxide content of the top gas is of the order of 9 per cent and that at the center of the furnace only 2 per cent, are due largely to the coarse material charged. It is true that in the case presented the ores used were of lower iron content than Lake Superior Ores; however, in this case crushing of these ores to a smaller size so that better gas-solid contact could be obtained would bring a higher carbon dioxide content of the top gas and a lower coke rate.

Various investigations have shown that large coke, say of the order of 6 to 8 inches in diameter, will cause a stock column which is too open and porous; this will also result in low carbon dioxide content of the top gas. In general, the sizing of materials should bring a better gas-solid contact. If ore, limestone, and coke were all of uniform size, the gas solid contact would be more uniform. As a matter of fact, the charging of sized materials to a furnace in Utah has made notable reduction in coke and has resulted in a faster running furnace.

Sintering

The return of raw fluedust to the furnace is not good practice because it increases production of fluedust and decreases tonnage of iron. Sintering is probably the best treatment for fluedust, as it helps in two ways: First, it removes the raw dust

from the charge; and second, it increases the average size of the iron-bearing materials in the charge by the introduction of the larger sizes in the form of sinter. Again, as the sinter is partly reduced when charged, it relieves the furnace of a small part of its work of reduction.

Power Economy†

By R. M. FULLER*

The creator of "Topsy, who just grew," if living in this day and age, must needs have conceived the idea of her character from the power systems of some of our industrial plant hangovers of modern times.

Such a power system is the one outlined in Fig. 1.

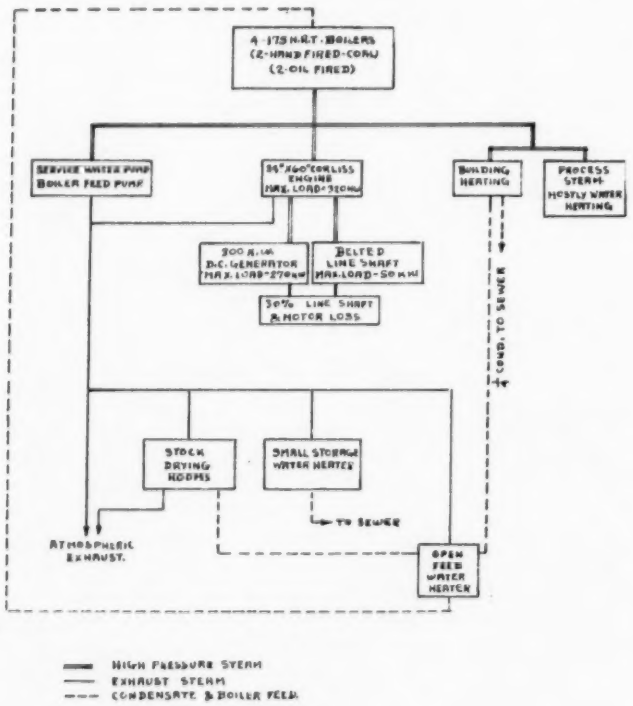


FIG. 1.

As it stood some two years ago, this plant was the legitimate field of the salesman for nearly every kind of power saving apparatus that is built. It was also the field of the power salesman of the public utility company of the district in which it is located.

The stoker manufacturer, the engine builder, the boiler control man, the maker of ball or roller bearings, could all have gone into the plant and individually have proved economies that by the combined use of their equipment would almost have run it without cost to the operator. However, the lucky first man to install his power saving equipment would immediately have changed economic conditions for all of the others.

It is with this phase of the economical installation for the generation and use of power that this paper has to deal; i. e., the relative return on invested capital when proposing to modernize an old industrial power system.

The plant outlined in Fig. 1 consisted of a twenty-two year old boiler plant; a thirty-five year old engine belted to a ten year old generator and one belted line shaft. An electrical survey of the plant showed that about 30% of load on the generator was in belting, line shaft and motor losses.

Of the boilers, two were coal hand-fired and two were oil fired. The oil burners had been installed during the war period when coal was difficult to obtain, the oil burning equipment at the beginning of 1927 having become quite obsolete and inefficient.

During the year of 1927 (which was prior to any major change in this power system) there was an estimated total steam evaporation of about 80 million pounds. Of this total about 17% was generated at nights and on Sundays, the balance during the 11 hour day period was used for power generation, building heating and process work.

The total hours of electrical energy used during this year was about 909,360 K.W.H.; the maximum demand about 360 K.W. These figures include the estimated horse power used by the belted line shaft, also the electric current purchased from the local utility company for night and Sunday lighting as the power generating equipment ran only on the average of 63 hours per week.

Only about 30% of the exhaust steam from the engine and pumps was used in heating and process work. A small amount was used for heating boiler feed water, the balance going to the atmosphere or sewer.

The approximate cost of operation for this plant for this year (1927) is shown in Table 1:

Table 1

Boiler fuel (coal and fuel oil)	$38,697.17
Engine and boiler room labor	9,204.00
Lubricating oil	470.43
Mechanical and electrical maintenance	1,287.70
Make-up water	500.00
Boiler compound	97.75
Ash disposal	530.00
Insurance	613.00
Purchased electricity (night lighting)	500.00
Engineering supervision	.....
Total	$52,530.00

Taxes are not included in the above as there are no federal, state or city taxes on the equipment in this plant and so far as depreciation goes, this equipment was written off the books long ago.

Ground rental and building investment have not been considered in this case as they become of

*Const. Engineer, Riverton, N. J.
†Presented Philadelphia Section, April, 1929.

prime importance only when new building is contemplated, or the need of additional space is required for the particular industrial plant under discussion.

The operating cost as shown in Table 1 furnishes the base from which all returns on capital invested to increase the operating economies of this plant must be taken, as quite naturally any return on the investment must result from a saving over these present operating costs.

Before going farther, let us consider these facts:

First, that where there is use for any considerable amount of heat that can be derived from the use of exhaust steam from an engine generating electric power, the solution of the power cost problem is not in the post per K.W. hour or H.P. hour of energy used, but is the total cost of steam and generated energy considered as a whole, though they may be obtained from separate sources.

Next, that the management of most plants is interested in the factors of invested capital, the return on that capital, and the relation of these two to plant production and capital structure.

And, that the result of any proposed scheme to make a more economical plant is in the nature of a hypothesis until it has actually been tried.

With these in mind, if we return to the plant under consideration it will be apparent that any one of a number of different investments, or combinations of them, should produce a considerable return.

Scheme A, which is the most obvious of these, would consist of converting the present high pressure heating and process steam systems to the use of low pressure steam to be obtained from the exhaust from the engine and pumps. To either convert the two oil fired boilers for the use of coal, or to purchase new and modern oil burning equipment for them. The old engine leaking steam badly due to worn cylinder and valve gear, can be rebored and a useful life of from 5 to 10 years obtained, at the same time improving its efficiency.

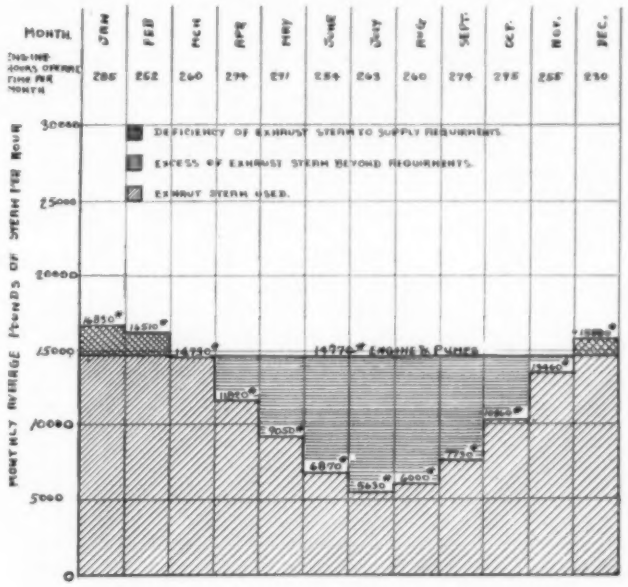
Scheme B would be additional to Scheme A and would consist of equipping the present boilers with stokers and boiler control meters, with the probable result of increasing their efficiency from an assumed 50% hand fired, to an average overall efficiency of about 65 to 70 per cent. However, it is quite apparent the return on this investment would vary, depending on whether it was applied in addition to Scheme A, or considered the logical first step to make.

Scheme C would be the installation of a new and modern type of prime mover direct connected to its generator, and of course would require the motorizing of the present belted line shaft.

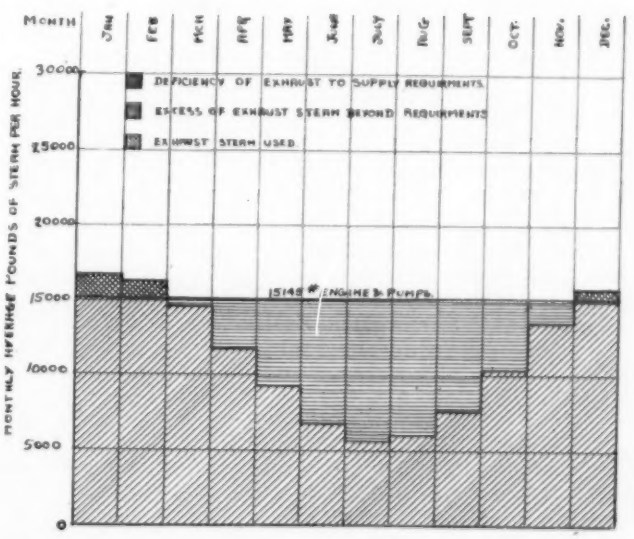
Scheme D is the alternate to these preceding schemes and would consist of the purchasing of all electric energy required for operating the plant, utilizing such exhaust steam as was obtainable from the pumps, and generating the balance of the steam required as at present, with the exception that it would still probably pay to install stokers and boiler control equipment.

These schemes which have been suggested are of course subject to many modifications and variations, any one or all of which would probably show a different return on the investment. Those suggested are not necessarily the ideal, but they are sufficient to show that which is desired.

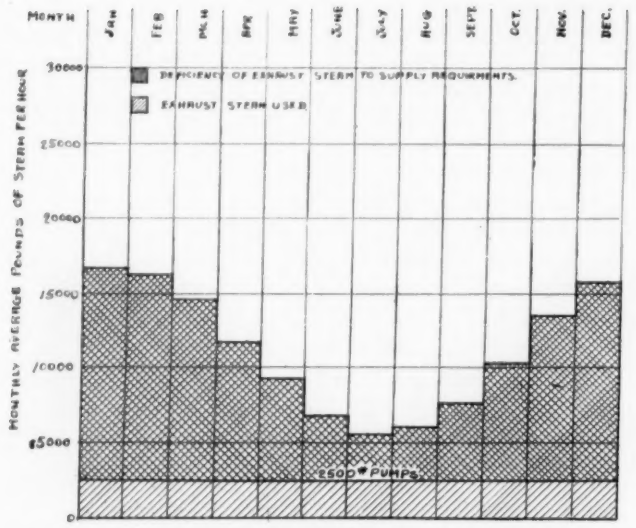
The charts marked Schemes A, B, C, D show in a general way what the steam conditions for a year of normal temperature and production would be under the above schemes A, B, C, D.



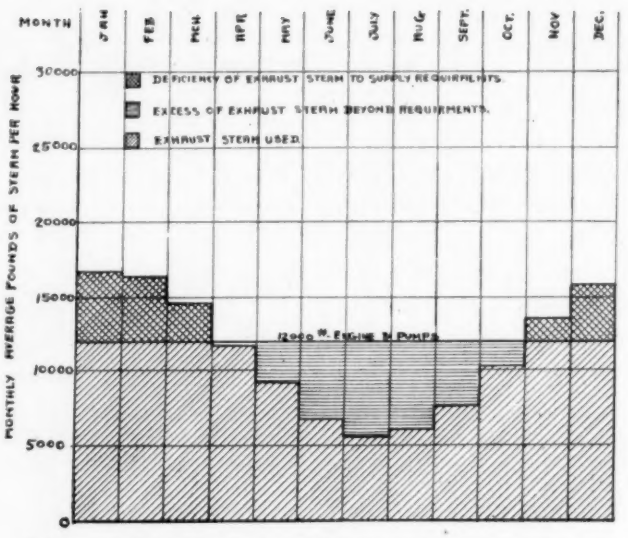
Scheme A—Exhaust steam utiiized for heating and process work. Present engine overhauled. All boilers coal-hand fired.



Scheme A and B—Exhaust steam utilized for heating and process work. Present engine overhauled. All boilers coal-stoker fired (only three required). Boiler control meters.



Scheme B and D—All boilers coal-stoker fired. Boiler control meters. Purchase all electric energy for power and lighting from outside source. Utilize all exhaust steam for pumps.



Scheme A, B and C—Exhaust steam utilized for heating and process work. All boilers coal-stoker fired (only two required—possibly three in winter). Boiler control meters. New modern steam engine and direct connected generators running non-condensing.

The estimated total new investment required by these schemes, and logical combinations of them, together with the estimated operating costs and return on investment is shown in Table 2.

The return on investment is based on:

$$\text{Return on investment} = \frac{\text{Base operating cost} - \text{Scheme oper. cost}}{\text{New investment}}$$

Table 2

Scheme	New Invest.	Operating Cost	Return on Investment
	Based on 1927		
1927	$.....	$52,530	..%
A	25,881	34,450	70%
B	17,000	38,321	84%
A-B	38,881	26,008	68%
A-B-C	65,805	22,784	45%
D	9,933	45,382	72%
B-D	22,933	34,662	78%
	Based on Scheme A Operating Cost		
B	13,000	26,008	65%
B-C	39,924	22,748	32%
	Based on Scheme A-B Operating Cost		
C	26,924	22,748	12%

In the case of the plant on which these hypothesis have been built, it is evident that the management of this plant will have to determine at the start just how they want invest their capital if they want to get increased operating economy in that department of their plant. Their main problem of course is to determine whether they want to continue to generate their own power with the knowledge that ultimately they must face a fairly heavy capital investment when the present engines and boilers wear out, or they must decide to purchase all electrical power and generate steam as at present. In the first case, though the investment is heavier and the return on it less, in the long run it will bring back the greatest sum of money. It also probably has the highest obsolescence factor, and it is this obsolescence factor, together with their ability to invest a like sum of money at such an attractive rate that would decide most problems of this kind.

To make concrete one of our hypothesis, it is to be noted that the plant in question proceeded with the work of installation of Scheme A during the year of 1928, with a total investment of $25,881. Those items of operating cost which were affected by the changes made during this year, after correcting for the difference in the cost of raw materials, showed a saving of $11,205 in the operating cost of the power plant department.

The change over being completed about the first of this year, enough time has elapsed to conservatively estimate the operating cost for 1929 and determine that the saving over the operating cost of 1927 will be about $16,857, or approximately on the basis of 65% return per year on the invested capital. These changes have also materially improved operating conditions in other parts of the plant.

Discussion

F. O. Schnure*: I do not believe I have anything to offer on this paper except to compliment the author on its presentation. It shows he went into the matter very thoroughly, and it is always very interesting to be able, after you change your plant to see what economies have been affected and how near you shot to the mark on your estimates.

Some years ago we started our Rail Mill after it had been idle five years. We started up with one engine, whereas it was originally driven with two, and those engines were fed from a steam boiler plant half a mile away. Of course the steam consumption was high, it cost us about $1.25 per ton and as there was a couple of motors at one of the other plants that were available for transfer, the question came up as to what saving we could make

*Supt. Elect. Dept. Beth Steel Co., Sparrows Point, Md.

by applying these motors. I do not know exactly what our figures were, but I think we figured a power cost of about 50 cents per ton. We actually saved about $1.00 as I think our power cost us 30 cents per ton compared to the $1.25 with steam. In that case it did not take very long to pay for the installation and improvements.

Martin J. Conway*: I would like to ask the speaker how much he was paying for his oil per gallon and the pounds of steam he evaporated; the pounds of coal equivalent based on his records of $52,000 per year operation. I think sixty million pounds of steam generated shows a steam cost of around 85c or 90c, which is rather high, or at least it seems high to me.

R. M. Fuller: I will have to answer Mr. Conway by saying I cannot furnish all of the details he asks. They were paying 5¼c for oil, as I recall the figure, when the boilers were converted from oil to coal.

As to the equivalent of evaporation, I cannot tell exactly. The conditions in this plant were such it was very hard at the time to isolate all the costs.

The figure for total steam generated in 1927 was 80 million pounds (I mispoke if I said 60), which makes a cost of about 65 cents per thousand pounds.

There was no doubt in my mind that it would have been impossible to carry the load they had in 1927 without the oil fired boilers, as they were carrying the tremendous surges and peaks on these boilers which the hand fuel coal boiler could not have handled with the change in the steam system to utilize exhaust steam from the engine, it became possible to operate with three boilers and a fairly steady load.

*Fuel Engr., Lukens Steel Co., Coatesville, Pa.

Electricity a Factor in Reduced Rolling Costs †

By C. M. THOMPSON, JR.*

Three years ago, we were faced with a breakdown on a 250 HP., Porter-Allen engine, driving one of our 9″ Merchant Bar Mills, which necessitated a major repair, or replacing it with either a new engine or an electric motor drive.

This breakdown offered the possibility to improve the mill conditions by the installation of a larger prime mover of higher speeds, which would permit the mill to be increased from 5 to 7 stands, and the rolling of heavier bars, thereby increasing production.

About this time, we were also required to increase the power factor of our load on the central station service to offset a penalty. This required approximately 700 KVA of corrective equipment. The purchase and installation of an automatic motor driven centrifugal pump for plant water supply had also been approved.

The selection of the most economical drive, therefore, developed into a broad engineering study of our power plant equipment with regard to future demands and operating conditions.

There were nine propositions developed in our consideration, all of which included the pump installation. These were as follows:

1. Repair the engine.
2. Repair the engine and install additional corrective equipment on central station service.
3. Similar to No. 2, except using capacitors instead of a synchronous motor on plant water supply pump.
4. Replace engine with an A.C. motor and 2-speed gear box with corrective equipment and additional transformer capacity.
5. Replace engine with a 2 speed A.C. motor, with corrective equipment and additional transformer capacity.
6. Replace engine with D.C. motor, second hand rotary converter and additional corrective equipment and transformer capacity.
7. Same as No. 6, except installation of a new rotary converter.
8. Replace engine with D.C. motor, synchronous M.G. set and additional corrective equipment and transformer capacity for minimum requirements.
9. Same as No. 8, except the installation of sufficient transformer capacity to allow more load to be carried from central station service and the rearrangement of our Power House bus to allow more flexibility.

Before outlining the merits of these nine propositions, it may be well to briefly present the power situation as it existed at that time.

Our rolling mills were all steam driven, with the exception of another 9″ merchant bar mill which was belt driven, from a 500 HP constant speed A.C. motor. The power house consisted of 3-750 KW turbine driven generators supplying 2400 volt, 2 phase, 60 cycle service to the plant. These turbines operate on 1.5 pounds pressure, taking the exhaust steam from the mill engines with live steam at reduced pressure to make up any deficiency. The economical point at which to operate, therefore, is to utilize the exhaust steam supply and carry all additional load on the central station.

Proposition 1, 2 and 3 were not further considered because no mill improvement would result. Also the installation of a new engine was not acceptable because the mill would then be dependent upon the boiler house, which, due to its age, would have

†Presented Philadelphia Section, April, 1929.

*Plant Engineer, Henry Disston & Sons, Inc., Philadelphia, Pa.

to be replaced during the life of the engine. This, of course, would involve a large expenditure.

Propositions 4 and 5 offered only two speeds, whereas a selection of several speeds would be an advantage on account of the great variety of sections rolled on this mill. Plate I shows some of these sections.

Plate I

The problem then became the selection of a variable speed electric drive. At the time of this study, we had the opportunity to purchase a 500-HP., D.C. motor, which had only run on an acceptance test, at a very attractive figure. For this reason a Scherbius drive was not given any further consideration. The study, therefore, resolved itself into the selection between Propositions 6, 7, 8 and 9.

Propositions 6 and 7 were considered only because a second hand rotary converter was then on the market. Proposition 8 offered the greatest possibilities so far as mill operation and power factor correction were concerned but supplied only sufficient additional transformer capacity to carry the load on the mill.

Proposition 9 was similar to Proposition 8 but included sufficient additional transformer capacity to allow all the electrical load in the plant over and above that which could be generated from exhaust steam to be thrown over to purchased energy. This proposition being the most economical was the one selected.

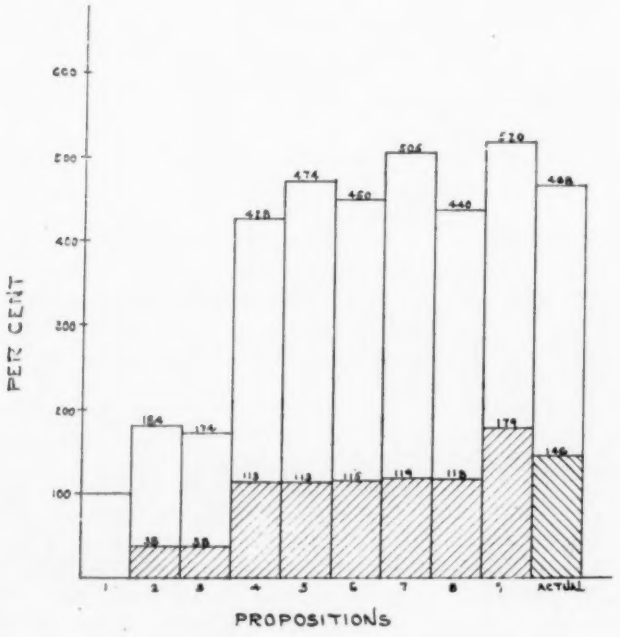


PLATE II

The comparative costs of these nine propositions, together with the estimated savings to be expected are shown on Plate II. The cost of the engine repair (Prop. No. 1) is taken as 100%.

The mill was moved to a new location and two more stands added. The 500 HP., 250 volt D.C. variable speed motor was direct connected to the flywheel shaft through a flexible coupling which in turn drives the mill through a set of pinions. A 700 KVA motor generator set with an 80% leading power factor synchronous motor was purchased and installed in the motor room to supply the direct current. Both the motor and the M. G. set are automatic and are controlled by means of a push button by the boss roller, thereby eliminating a motor operator. A drum type controller mounted outside the motor room permits the roller to vary the speed of the mill and a reversing switch also enables him to back off in case of a bar sticking in mill or the breaking of a roll.

A run-out table 125 ft. long with hot bed and motor driven rollers carry the finished material to the shears. A portable electric variable speed reel is used for coiling. Plates III, IV and V are views of this mill.

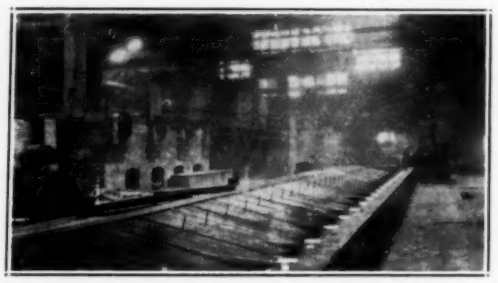


Plate III

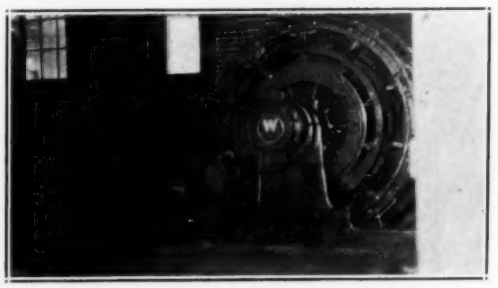


Plate IV

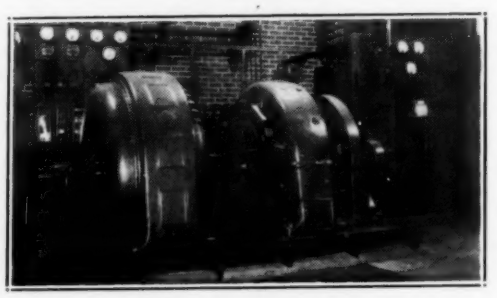


Plate V

The estimated saving was based on increased production due to higher mill speed and heavier billets, lower power cost, lower maintenance and avoidance of penalty for low power factor. The

speed of the mill when engine driven was 250 RPM while the variable speed motor gives a range of from 200 to 400 RPM. The average increase in the weight of billets is 50%. The power factor on the central station service is now 97.6 according to the Philadelphia Electric Company test.

Referring again to Plate II, the last column shows the actual cost of the D.C. motor driven mill, together with the total actual saving accomplished in 1928, the first year of operation. While the actual saving is not as great as estimated, the increase in production was 23% over the steam driven mill with the same mill gang, although the estimate was based on 2000 hours, operation whereas the actual was only 1547 hours.

On this basis, the investment will pay for itself in a little over three years.

Discussion

F. O. Schnure*: I have not very much comment relative to Mr. Thompson's paper, except to state that it looks like a very complete analysis of rolling mill problems. In the last column of his analysis before he mentioned the figure, it looked as if the saving would represent about a 30% return on the original investment, which is a good return for replacement of this nature.

I also believe they were correct in adopting d.c. variable speed drive on the rolling mill. The trend of rolling mill drives is toward d.c. on account of the flexibility that can be derived from such drives in preference to the constant speed a.c. drives. I really believe that the steel mill drives in the future will lean more and more toward d.c. drives.

R. F. Gale†: I would like to know how many men were eliminated when the engine drive was superseded by the electric drive, and what was the estimated saving per man per year.

*Supt. Elect. Dept., Bethlehem Steel Co., Sparrows Point, Md.

†Plant Engineer, The Midvale Co., Nicetown, Philadelphia, Pa.

J. G. Walz‡: The fact that there were nine possible choices in this problem shows that every problem of electrification and steam drive or any other mill is a separate problem. There are no hard and fast rules to be laid down on this thing. That he was able to pay for his electric drive in three years shows that it was more than justified in actual savings. The cost of electrifying a large mill is rather hard to get at, but we had one of our 44-inch blooming mills on which we had used an excessive amount of oil in a month for the lubrication on a 5,000 h.p. engine. We put a 6,000 h.p. motor on this same drive and it took about one barrel of oil a year. Of course, the oil just went into that engine for months and did not get into all the bearings. It is practically impossible to keep all the lubricating systems tight, and when we came to put in the foundations for the motor we found a lot of oil. That is one instance of what may be accomplished in electrifying a mill.

Walter H. Burr°: I do not think there is much to add to what has already been given in the discussion. I do think that Mr. Thompson is to be complimented on the completeness of his paper. He has taken into consideration all the various points that I believe should be considered, and it is very evident from the saving made that the selection was right.

C. M. Thompson*: Answering Mr. Gale's first question, there was actually no labor saved on this mill. It so happened, with the layout of our mills, one engineer took care of our 9- and 18-inch bar mills. His time, of course, was split between the 9- and the 18-inch. The new installation did not eliminate that man because he was still needed to handle the 18-inch mill, although half his time was wiped out through the automatic control of this mill.

As to the value of the man, we generally figure in the neighborhood of $2,500 a year for an engineer.

‡Asst. Supt., Elect. Dept., Bethlehem Steel Co., Steelton, Pa.

°Lukens Steel Co., Coatesville, Pa.

*Smoke Abatement in Industry**

By MARTIN J. CONWAY†

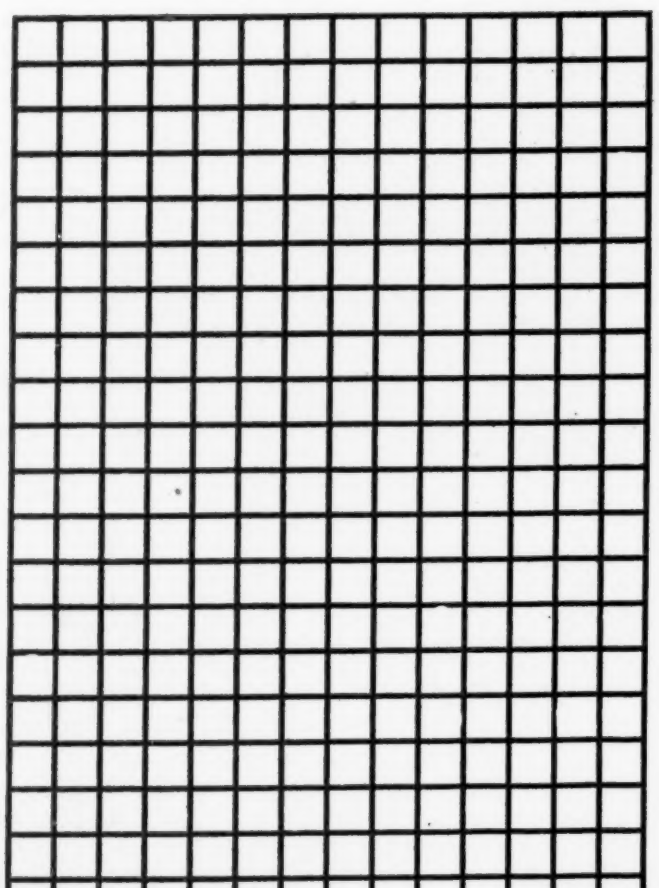
I must first of all make an apology for talking to you about a very old subject, but it is one that is fast becoming important to the industries which are located in crowded communities, and as recent as 1914 a group of men undertook to study smoke conditions in Pittsburgh, made possible by a fund of $10,000 provided by Mr. R. B. Mellon. Smoke is the most visible polution of the air. In the last fifty years the cities of our greatest industrial activity have been the greatest offenders. There are many reasons for an effort to cut down the smoke output, among them being fuel economy, cutting off of light, etc., but the most important reason is the harmful influence of smoke on the health of those who must daily breathe it. While smoke does not contribute 100 per cent to the unsoluble matter deposited in the street, homes, offices and other dust resting places, it is interesting to note what is apparently industry's contribution to this nuisance. The following figures were published by the Mellon Institute of Industrial Research, they are the average of the amount measured in more than 10 stations in each city.

	Pounds per Sq. Mile, per year
Cincinnati	1,036,000
St. Louis	1,320,000
Pittsburgh	3,120,000

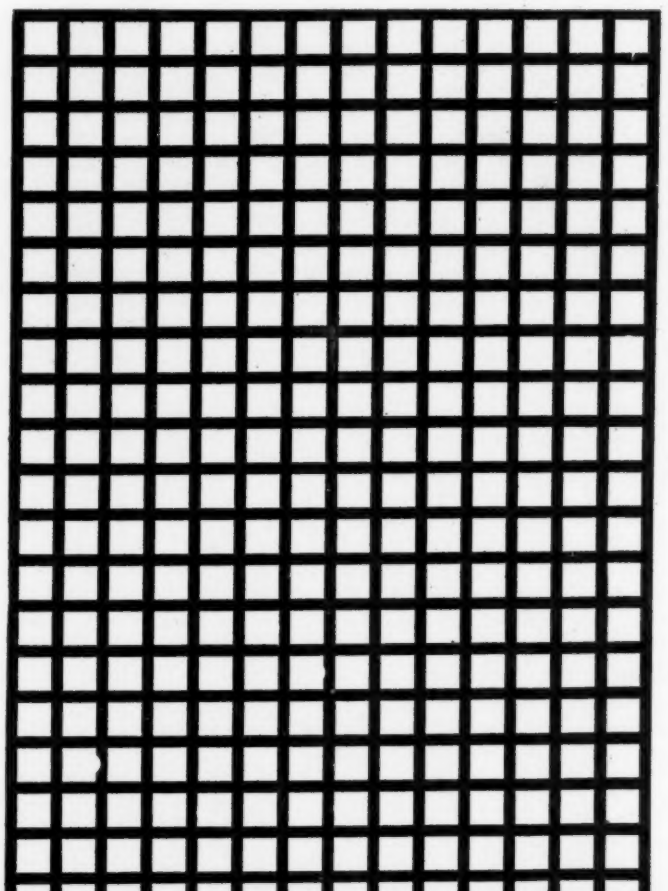
We are told that carbon particles suspended in

*Read before A. I. & S. E. E., Philadelphia Section, Saturday, April 6, 1929.

†Fuel Engr., Lukens Steel Co., Coatesville, Pa.



1. EQUIVALENT TO 20 PER CENT BLACK.



2. EQUIVALENT TO 40 PER CENT BLACK.

the air we breathe may lodge upon the surface of the breathing apparatus from its beginning at the nose to the smallest air vesicle in the depths of the lungs, and, that the immediate response to such an irritating foreign body is a pounding out of fluid in its neighborhood. The direct result is that any pathogenic organism gaining entrance to the respiratory tract in the following of the carbon, finds a medium ready at hand for its rapid multiplication. Whatever may be the explanation we do know that smoky communities are not associated with ruddy complexions except of the drug store variety.

The bulletins of the Mellon Institute tell us that smoke and other items of air pollution fill the atmosphere with acrid poisonous compounds and soot particles which irritate the sensitive membranes of the eyes, nose, throat, lungs and gastro intestinal tract, increase the susceptibility of gastro-intestinal, pulmonary and naso-pharyngeal disorders, diminish the potential reserve, working capacity and well being of the individual, increase fatigue, irritability and malcontent, and may tend to hasten premature decay.

The smoke content and other impurities in the air have an apparently important bearing on the pneumonia death rate and comparatively little effect on the tuberculosis death rate.

Smoke and other solid particles in the atmosphere lessen the duration and intensity of sunshine, reduce the intensity of daylight (the light of short wave lengths or the blue light, suffering the greater depletion), the limit of visibility and the diurnal winter temperature, increase humidity, mists and increases the frequency and duration of fogs.

Humidity increases the solid, poisonous, bacterial contents of the air, aggravates various pathological conditions of the body reduces the sensitivity of some sense organs, and depletes the vital potential. Fogs increase the prevalence of diseases, and augment the death rate.

Clear days produce a superabundance of energy, dark clouds have a depressing, devitalising effect.

Smoke, dust clouds and acid fumes seriously limit not only the possibilities of municipal art, in respect to architecture, statuary, painting and ornamental gardening, but also limit the possibilities of art education in the community in question. They begrime, deface, decolor, destroy and corrode interior and exterior artistic effects of color, brick, stone, marble or metal. Smoke clouds befoul the persons as well as the dress of the people, limit the range of wearing apparel, and help to foster habits of indifference.

The estimated economic cost of the air pollution nuisance to Pittsburgh (1912-13) was $9,944,740 per annum. No estimate has since been made to determine the economic effect of smoke abatement. St. Louis, Missouri, estimated her loss for 1926 to be $15,532,000 or $18.82 per capita.

Recognizing this economic cost many cities have ordinances regulating the production or omission of

smoke from any chimney or smoke stack within their corporate limits. The method of enforcement being to compare the color of the smoke being emitted to the Ringleman Smoke Chart shown in Figure I, the limit usually being equal to or denser than No. 3 of the Ringleman Smoke Chart.

However, the large industrial plants have done much during the past fifteen years to eliminate smoke and it is the smaller specialty plants which are now the chief offenders.

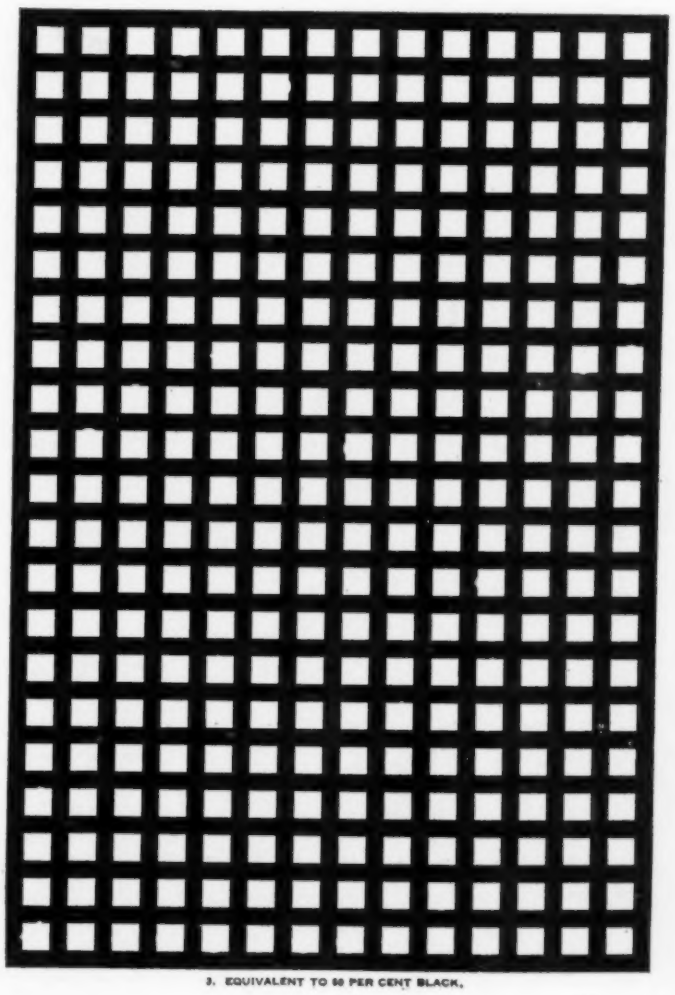
The economics of almost all large industries force the use of bituminous coal as the chief fuel and from it practically all heating and melting operations are performed.

The process of combustion is comparatively simple, being the chemical union of the combustible material of a fuel with the oxygen of the air resulting in the development of heat. However, in practice many difficulties are encountered which tend to make the process complicated, and it is in overcoming these difficulties that care is required in the operation and sound engineering in the design and construction of furnaces. The number and nature of the difficulties vary considerably with the fineness of the fuels, the type of furnaces used, and amount and composition of the impurities in the fuels, and the load demand on the furnace.

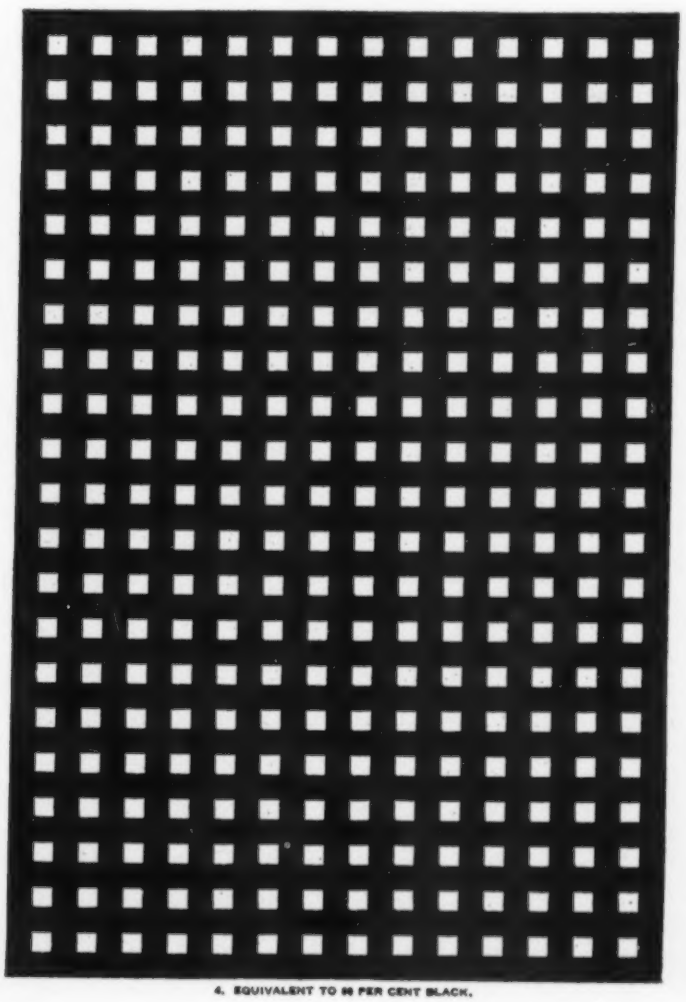
There are three distinct and separate stages involved in the combustion of coal, first there is absorption of heat. When fresh coal is fed to the furnace, its temperature must be raised to the kindling point in order that combustion may begin. Second in order is the distillation and combustion of the volatile portion of the fuel, and third, the combustion of the remaining carbonaceous portions of the fuel. If the fuel is high-volatile bituminous coal, this expulsion may amount to 33 or 38 per cent by weight of the total; and if, as in hand fired furnaces, the feeding of fuel is intermittent, large volumes of volatile matter are distilled off in a very short time after each fuel addition. It is during this period of distillation that dense smoke usually is emitted. If the furnace temperature is sufficiently high and a sufficient volume of oxygen is present, the volatile matter will be burned above the fuel bed. For complete combustion it is necessary that a sufficient temperature be maintained in the furnace, that the furnace have sufficient volume to permit the gases to be held long enough for completion of combustion, and that there is proper provision for the admission of a sufficient volume of air, the internal construction being such that the gases from the fuel will be thoroughly mixed with the air provided.

After the hydrocarbons have been driven off and more or less consumed, the remaining portion of the solid matter is composed mainly of carbon and ash.

It is comparatively simple to secure complete combustion at this stage, so that the solution of the smoke problem deals largely with the combustion of the products evolved in the second stage of combustion. Therefore, the smokeless combustion of



3. EQUIVALENT TO 60 PER CENT BLACK.



4. EQUIVALENT TO 80 PER CENT BLACK.

bituminous coal depends upon the construction and operation of furnaces in such a manner that the volatile products evolved in the second stage of combustion are completely consumed before they strike any cooling surfaces, which will reduce their temperature below the kindling point. Briefly stated, the principles involved to secure these results are:

Air in sufficient quantities for complete combustion must be admitted at the proper time.

The air must be thoroughly mixed with the gaseous portion of the fuel.

The temperature of the gases must be maintained above the kindling point until the chemical process known as combustion is complete.

Smoke abatement does not inflict any hardship on the manufacturer, but in many instances results in a direct saving of fuel, better quality product and more satisfied labor.

The larger plants of the steel industry have greatly improved their practice during the past fifteen years, but there is still room for improvement on the smaller heating and annealing furnaces which are producer gas or oil fired.

The practice of discharging the products of combustion into the shop and the employment of stackless furnace is not conducive to ideal working conditions and tends to damage the buildings. A well ventilated shop with the furnace gases conducted to the outside by a stack is a much more economical operation than a stackless furnace, discharging the products of combustion inside of the shop, no matter how perfect combustion may be.

The larger steel plants which are equipped with by-product coke ovens have also done much to cut down atmospheric pollution. The gas produced by these installations is rich in fuel value and is comparatively easy to handle and automatically controlled and can be burned smokelessly.

These by-product ovens also contribute a large tonnage of smokeless domestic fuel for the individual consumer.

The industrial plant whose stacks emit large clouds of black smoke is no longer a sign of industrial prosperity but rather an indication of fuel waste and indifference to the welfare of the surrounding community.

DISCUSSION

H. K. Hardcastle*: In using that chart in making your comparison, is it a matter of colors in the smoke that goes out of the stack?

Martin J. Conway: The chart is placed a sufficient distance from the operator to allow the lines to merge together and form a solid shade. Usually when smoke is found of a deeper shade than No. 3 Ringleman Chart, the Superintendent of the offending plant is notified and efforts made to stop the offence. There are very few instances, where the use of modern equipment, if properly operated, will not utilize fuel smokelessly.

F. O. Schnure†: I understand in the pulverized coal installation the ash goes out of the stack?

Martin J. Conway: Yes, sir.

F. O. Schnure: How do you regulate the smoke abatement?

Martin J. Conway: It is true that a pulverized coal installation will emit a certain amount of dust, but with correct draft regulations this dust can be kept at a minimum. The most harmful product in this case would be the sulphur from a high sulphur coal, but the dust is not as harmful to the community as the carbon in the stack gases, so therefore is not as offensive. However, it is highly desirable to keep the dust in the gases down to the minimum.

Norman C. Bye‡: Isn't there some other form of smoke comparison beside the chart you have shown?

Martin J. Conway: There are other forms of smoke density comparison besides the Ringleman Chart which have been used with more or less success, but for obtaining quick readings with a reasonable amount of accuracy there has not yet been devised a method that is an improvement upon the Ringleman Chart comparison.

*Electric Controller & Mfg. Co., Witherspoon Building, Philadelphia, Pa.

†Supt. Elec. Dept., Bethlehem Steel Co., Sparrows Point, Md.

‡Henry Disston Sons, Inc., Tacony, Philadelphia, Pa.

Fabricated Direct Current Machines

By R. S. MARTHENS* and F. T. HAGUE†

The introduction of completely fabricated types of rotating electrical machines within the last few years is of particular significance to steel mill engineers. Not only has a wider field of application been opened up for their product, but its introduction has materially contributed to the development of better designed and more reliably built electrical machines. The extended application of the fabricated arc welded type of construction has completely revolutionized electrical design methods and has proven to be the incentive for the development of better and stronger structures in every element of the machine.

It may not be immediately apparent that the development of the arc welded fabricated construction should affect electrical design methods. For forty years, electrical designs have been built around cast type structures until the economic limits of the cast type structure have come to be accepted as inevitable. The limitations of foundry practice and the cost of patterns have been insurmountable barriers to the design engineers' ideals. Standard lines of ratings, only, could be developed at reasonable

*Mechanical Engr., Power Engineering Dept., Westinghouse Electric & Mfg. Co.

†D.C. Division Engr., Westinghouse Electric & Mfg. Co.

costs, owing to prohibitive development charges for special ratings. The percentage of special machines for the Steel Industry is steadily increasing, owing

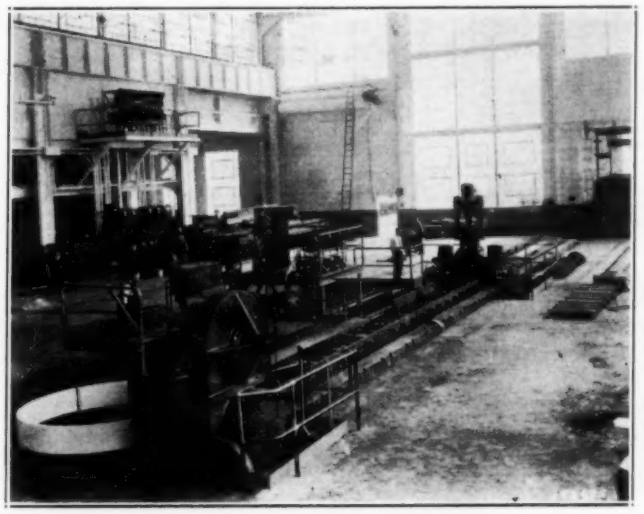


FIG. 1—Frame—Rolling Mill.

to the outstanding advantages of electric drives and its adaptability to all sorts of mechanical requirements. This requirement of the steel mill industry has not, under past conditions, been attractive to the electrical manufacturer, but wisdom requires that ways be found to meet this condition with as little sacrifice of manufacturing economy as possible.

The development of arc welding has entirely changed the situation. Every new design no longer must finance the cost of a pattern for each new part. A rational design free from the limitations of foundry practice is now possible. Steel at $.02 per lb. is cheap and structures of ample strength are no longer secured only at a high premium.

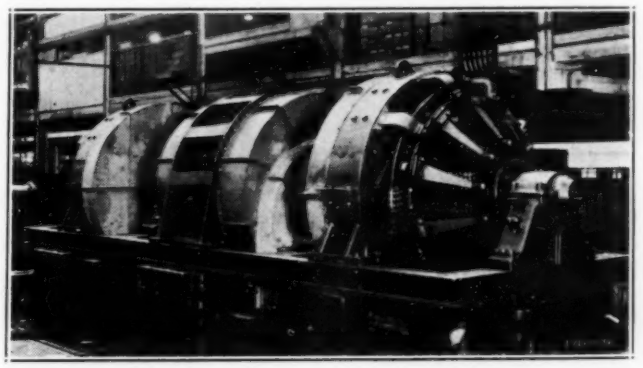


FIG. 2—2000 KW., 250 V., 3-unit M.G. Set.

An existing line of direct current machines using castings cannot be changed over to the arc welded fabricated construction simply by replacing castings with similarly shaped fabricated constructions, without sacrificing many of the attractive possibilities which the new method of construction makes possible. A particularly valuable feature of fabricated construction in direct current machines of medium and large size is the design flexibility of the arc welded construction that permits a wide application of any given element of the machine. This feature alone has an economic aspect which justifies the complete redesign of the entire line of machines to take full advantage of all the opportunities of flexibility in design which are the arc welded fabricated construction alone makes possible. Through this design flexibility, the manufacturers' ideal of building a special machine in the same time and without appreciably more cost than a standard rating, comes very close to realization. This is possible because the fabricated construction lends itself ideally to the "standard part" plan of manufacture.

Basicly, the standard part plan means the separation of the machine into parts or elements, some of which can be used in many different designs and others of which will generally change with every design. The major mechanical elements, such as frames, armature spiders, and punching blanks will obviously be constant parts that can be standardized or simplified. Windings, in general, will be variable elements that will change with every rating. The purpose of the plan is to reduce the standard parts to the minimum number of sizes and so to organize the methods of design of complete machines that a given standard part will be used in as wide a range of ratings as possible. The fabricated construction alone makes this plan feasible without incurring prohibitive development charge for patterns, etc. There is nothing new in the idea itself. Reduced to its simplest form, it is the idea, for example of building an infinite variety of houses from one size and kind of building brick and a small number of sizes of standard doors, window sash, etc. It has been used for many years in control and switchboard building. The new thing worthy of note is the application of this old idea to the internal parts of complicated electrical machinery and in such a

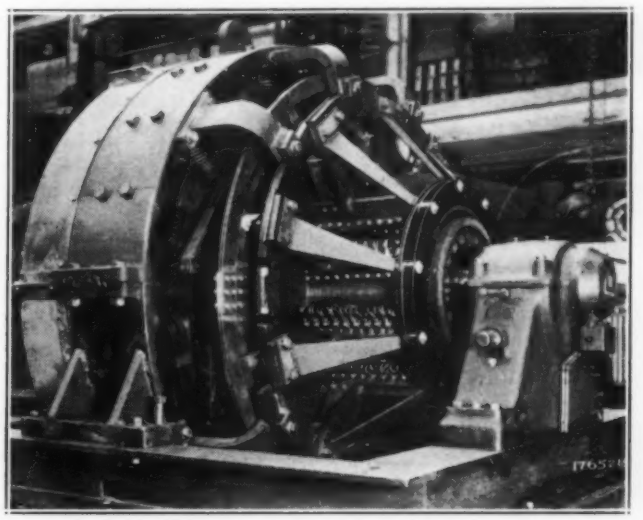


FIG. 3—1000 KW., 250 V. Generator.

way as to meet the exacting performance requirements demanded by the present advanced state of the art. This standard part idea was first applied to a line of engine-type synchronous motors and generators eight years ago, has been extended slowly, and has recently been applied to the more complicated case of commutating machines in such a way as to meet exacting performance requirements.

Successful application of this idea requires a complete change in the designer's objective and method in designing the entire line of machines. The unit of design is no longer a single rating with the prob-

lem of making the best possible special design for that rating alone. The new unit is a single part—a frame, main pole, armature punching, commutator, etc. The problem is to design that part so that the desired range of ratings can be built satisfactorily with competitive performance, with the minimum number of sizes of that part, and to design the individual part so that it will have a rational application when assembled into completed machines. Some parts of the machine will necessarily vary with every rating, but these parts are essentially electrical and are not important from the standpoint of welding applications. The essence of the standard part plan of fabricated construction is to simplify the design of the product so that mass production technique can be applied, as it is recognized that low manufacturing costs result from standardization and mass production. In the direct current machinery business, there is not a sufficiently large volume in number of units to be concerned with mass production methods. The real significance of mass production, however, is not so much the quantity of production as it is the simplification of the product. The important concept is not so much large quantity as it is small variety of design.

The standard part plan of manufacturing technique includes the generous use of time study methods, the complete application of time limits to all operations before production is started, the use of universal type tools, jigs and fixtures to a degree not economically feasible under the old system, specialized machine tool equipment in many cases, and a minimum number of set-ups by adopting economical manufacturing quantities and stocking standard parts. This is all possible when the factory is dealing with a limited variety of standard parts, but is obviously out of the question when the same output is produced from individual special designs.

It might reasonably be expected that the completely fabricated machine would involve a large amount of intricate welding. It has been a revelation to many engineers to find the relatively small part which welding can be made to play in the construction of a typical fabricated D.C. machine. Just as style is a matter of design in building automobiles, so strength and safety can be made a matter of design in rotating machine manufacture. Skill in design, rather than brute strength in welding, has been called upon to avoid complicated welded structures that the ultra-conservative engineer might consider questionable at the present time. The development of a new armature construction for large machines wherein the centrifugal forces of the armature core and windings are not carried through any welded joints and the use of through bolts for segmental armature cores and all commutators are examples of design practices that no entire line of commercial cast type designs can economically justify.

The standard part plan of fabricated construction greatly simplifies the welding problems by reducing the variety of welds to a small number of standard types. For each of the relatively small number of standard parts, a master design is created and each element manufactured is identical in design and differs only in physical dimensions. The manufacturing problems and the welding technique required can obviously be given the utmost consideration in view of the limited number of parts involved. For example, it has been possible, with but one exception to design the entire line of standard parts using only four sizes of simple fillet welds. In analyzing the application of arc welding to the rotating members of D.C. machines, it must be remembered that the application is new and ultra-conservatism in the welding application is considered desirable at the present stage of the development.

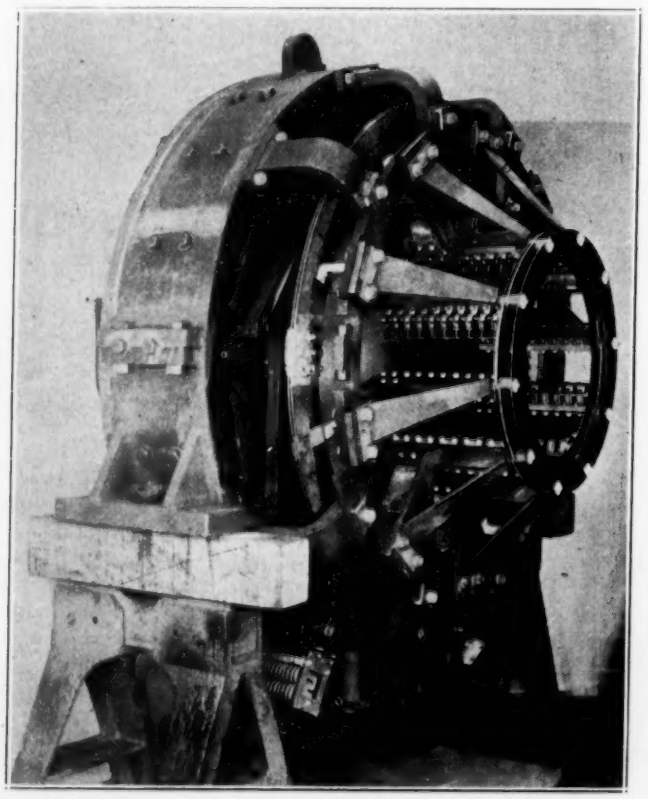


FIG. 4—Stator and Brush Rig of Typical Generator.

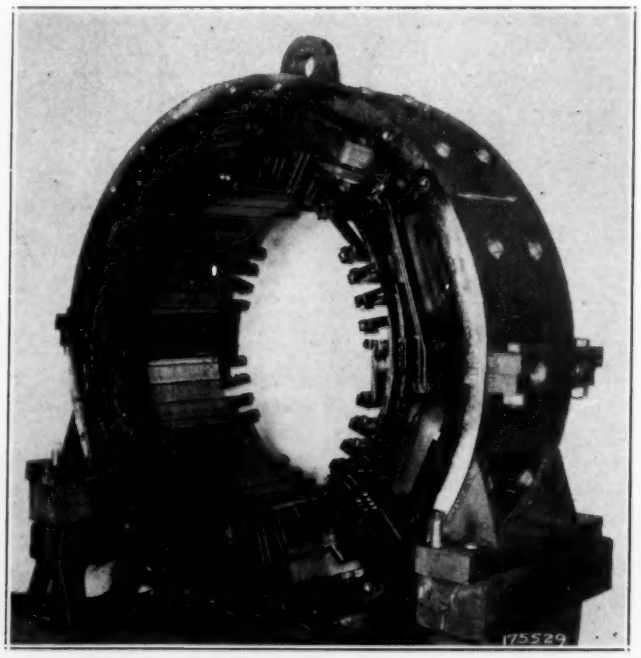


FIG. 5—Stator Field Assembly of Typical Generator.

The rotor design of the fabricated D.C. machine is an outstanding illustration of the safer and stronger constructional features that this fabricated type of construction makes possible. The mechanical safety of the rotor is a fundamental requirement and is best assured by making it independent of all welding. The rotor core can meet this ideal only by having its segmental punchings arranged into a self-supporting ring so interlocked by steel pins that the entire unit is self-supporting as regards centrifugal force, and is merely centered and driven by its fabricated spider. The core construction is further safeguarded by being held together by through bolts which maintain the core pressure.

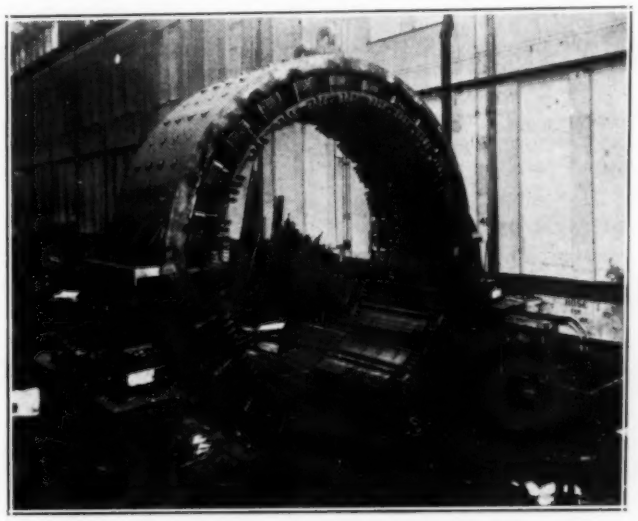


FIG. 6—7000 HP. Motor—Rolled Frame.

The armature spider is composed of two hub rings and the necessary arms, both burned from steel plates. The spider arms are notched by gas cutting to receive the hub rings. The end plates, as well as the commutator supporting ring, are also burned from steel plates. With the arms notched to receive the hub rings, ample welding can be applied to obtain conservative weld stresses under the most severe operating conditions. Unyielding elements which are rigidly held apart and are unable to approach each other slightly when the welding metal cools, should not be joined together by welding. As an example, armature spider arms are not welded to both the unyielding hub rings and the armature core element. They are welded to the hub ring only and are attached to the core through a simple mechanical press fit connection. Avoiding difficult welded structures eliminates the necessity of annealing parts after welding.

Simple fillet welds of small size should be used. Welds of large cross-section are less desirable in that they require a large amount of weld metal per unit of strength, and are less readily inspected than small welds. Being built up in successive layers, the large weld is rather more subject to unequal stress distribution due to temperature effects during cooling. Stresses in welds must be ultra-conservative, even under the condition of short circuit on the machine. The value of short circuit torque has been determined and a large factor of safety has been used in the application of the welds. On rotating part, the welds must be stronger than the steel parts joined together.

The only stress in welds and hub rings is that which is set up by the transmission of the torque and this is easily determined for any specific design. Sample armature and hub rings have been made and tested with several amounts of welding. In the final design, a structure has been selected wherein the welds are much stronger than the steel in the arms. With this type of rotating part design, a much more substantial rotor is obtained than is possible by the use of castings and the old type of mounting punchings on dovetails. In addition to improving the mechanical safety of the rotor, the new construction is much more open and by giving better ventilation, insures more output from the machine.

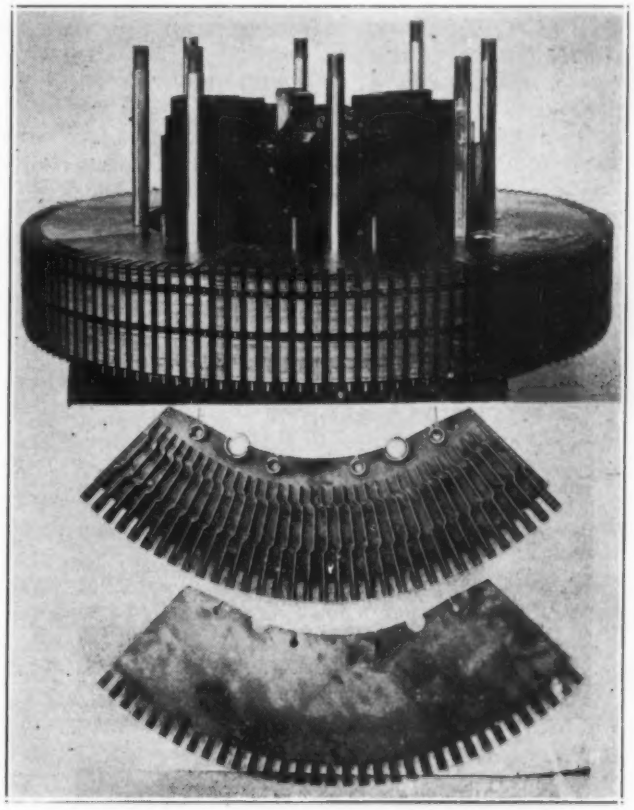


FIG. 7—Building Up a Fabricated Rotor.

The commutator construction is so arranged that the centrifugal forces of the copper bars and steel vee rings are not carried through any welded parts. Independent front and rear rolled steel vee rings hold the copper bars firmly in position by through bolts. The assembly is entirely self-supporting, and is merely centered by its fabricated spider. The commutator may be attached to the armature spider to permit removal of shaft without unsoldering any connections.

The magnet frame is made up of steel bars and slabs joined together by arc welding. All welds are located on the outside and are of the simple fillet type. The frame foot welding must withstand the stresses due to electrical short circuits of the machine and these welds have been calculated to have an ample factor of safety under this condition. The welding at the split of the frame and on the lifting lugs is determined by the weight of the parts,

and the permissible deflection of the frame, rather than by load torque conditions. These welds have been calculated to withstand the stresses due to handling in the factory, and installation of the assembled stator.

The brush rigging is of the heavy duty rocker ring and brush holder bracket type and is completely fabricated, all pieces being held together by arc welding. It is believed that fabricated steel parts have a greater tendency to vibrate than do cast parts, and this has been recognized in the layout of the new structure. Various samples have been built and their comparative rigidity tested. The final design is a substantial rigging, more capable of standing severe service than the replaced cast constructors. All welds are of the outside fillet type, the parts being so arranged that electric current does not pass through any of the welds. The rigging is made in halves, being bolted together to facilitate installation and dismantling in case of repairs to the machine. The rigging is also capable of being readily shifted to obtain the correct electrical neutral position. The brush holder brackets are made of two steel bars joined at right angles by arc welding, the horizontal bar being notched to receive the vertical bar. Rigidity is obtained by a brace between the outer end of the horizontal bar and the vertical bar.

The entire line of machines covering ratings from 300 to 8,000 HP. in voltages from 250 to 1500 volts, comprising ampere ratings as high as 15,000 per armature, uses but four sizes of D.C. brushes. This represents an important contribution to the Steel Industry's efforts to secure standardization of brushes and is cited as an example of one of the by-products of the redesign of an entire line of machines. Die cast brush holders of bronze are used exclusively.

The field winding structure is another important by-product of the complete redesign, and embodies a greatly simplified and stronger construction for all parts. The main field winding is now wound directly onto the field poles without the use of any moulds. An enormously tighter winding is obtained with better heat dissipating ability. Completely wound field poles, when tested on a vibration machine, showed more than 100 times the ability to withstand vibration without becoming loose than coils wound in moulds and assembled with the older type of bracing.

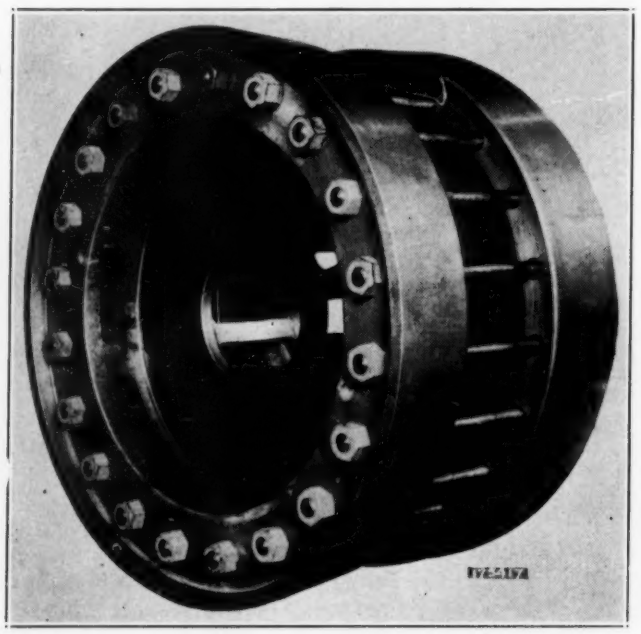


FIG. 8—Typical Through Bolt Commutator Assembly.

The fabrication of a line of machines requires considerable special factory layout and equipment. The full advantages available from the arc-welded construction can only be realized by courageous scrapping of existing manufacturing equipment, and the installation of new equipment of novel type. In place of the foundry, there will be substituted furnaces and bending rolls for the rings used in the direct current frames. In place of the machine tools, there will be automatic gas-cutting machines, and finally, automatic welders, etc., required for fabricating. Thus, there are heavy initial development costs that must be incurred before manufacturing can begin.

The designs must be made in close co-operation with the manufacturing engineers that proper allowances and tolerances will be made for mill variations in the dimensions and flatness of steel shapes, the unevenness of burning, and the distortion due to welding. The sequence of manufacturing operations which will give low cost very often calls for new ideas. With fabricated steel parts, it is frequently possible to omit entirely certain machining previously required in the use of castings. The designer must keep in close contact with the manufacturing engineer, as many new developments may thereby be applied to parts other than the one which led to their inception.

The control of the design of shop tools and fixtures is an integral part of the design of the machines themselves. The problem of tools and fixtures is more difficult with fabricated steel parts than with castings, one of the reasons being the greater design flexibility inherent in the fabricated construction. It is essential that this flexibility should not be restricted too greatly by shop tools and fixtures, and it is frequently a problem whether to provide a universal fixture, or one applying only to a particular size.

The manufacture of the various parts is laid out so that the cutting, cleaning by shot blast preparatory to welding, and the welding itself, is completed with a minimum of handling. Frame rings are bent, cleaned, and accessories welded on in the same shop section by a single group. The rotating parts, however, are handled by a separate group on account of the higher grade of workmanship required. The small variety of types of designs has been found to facilitate good welding. The welders of this group are selected from those who have received training in the welding school and have shown special aptitude in regular production work of less importance. The supervisors and inspectors are chosen with a view to securing good welding and reliable inspection of the welding process, as well as the finished product.

Special equipment is essential to produce some of the parts for direct current machines, such as for example, the equipment for the manufacture of heavy frame rings. The equipment for making these rings includes a furnace for heating the heavier slabs for

bending. It is desirable to heat slabs of more than 3½ inch thickness before they can be formed into rings. A set of motor-driven roll tables with hydraulic turn-over apparatus, handles these slabs from one operation to the other. A crimping press and a vertical three-roll bender completes the equipment for the manufacture of the rings. The crimper is a 1,000-ton hydraulic press equipped with dies for bending the slab ends before they go through the bender. This makes it unnecessary to cut off or bend by hand the straight ends left when such rings are bent in a three-roll bender. It is unnecessary to provide a die for each diameter as one die can take in a range of diameters by proper manipulation of the press. The press is supported on roller trunnions so that it can spring with the piece being bent, thus allowing the rest of the piece to be flat on the roll table. After crimping both ends, the roll table carries the piece to the "pick-up," which turns the slabs on edge ready to be entered in the bender.

The bender is a vertical three-roll machine with motor-operated rolls and an individual motor-operated screw down. The screw-down is made heavy enough to bend the piece by centering the slab and operating the screw-down motor. This makes it possible to begin the bending operation from the center of the piece if desirable, or to bend without allowing it to pass out of the rolls. Guide rolls are used to support the free ends of the rings to prevent possible distortion while bending. The bender is capable of handling a slab 36 inches wide and 3.5 inches thick without heating. The smallest diameter ring that can be made is 30 inches with no limit to the maximum. It will also edge-bend rings 2.5 inches thick and 12 inches wide to 60 inches minimum diameter. The controls are centralized at a pulpit placed so that the furnace door and car, roll tables, crimper, and bender may be under the control of one man who can oversee all of the operations.

The welding fixtures are all made from structural shapes and are completely welded together, taking advantage of the adaptability of this material for such parts. The fixtures have been designed with particular attention to securing the best arrangement for assembling the parts and for ease of welding. These welding fixtures, wherever possible, are made so that only one fixture is required for each part of the line, regardless of its size. This feature has been secured with no sacrifice of the adaptability of the part or undue complication of the fixture. In order to take the greatest advantage of the possibilities inherent in this type of construction, it is necessary to allow much less stock for machining than has been needed for castings. To accomplish this result, adequate welding fixtures must be provided so that the parts are held in proper relation to each other, and the welding done in a way to produce a minimum distortion of the finished parts.

The raw material necessary to manufacture both the rotor and stator is carried in stock either in mill lengths or multiple lengths for that part for which it is to be used. The investment needed for a complete stock of this kind is small compared with that which would be needed to carry an equivalent stock of castings. It is quite probable that the investment and the handling of a complete stock of castings for such a line of machines would be prohibitive under any manufacturing conditions.

Inspection Trip Pittsburgh and Cleveland District Sections Association of Iron & Steel Electrical Engineers

Over two hundred engineers representing steel plants from all over the United States attended the Inspection Trip to the Central Alloy Steel Corporation and the Timken Roller Bearing Company's plants at Massillon and Canton, Ohio, Friday, October 25th, 1929.

This trip was an education for those who were fortunate enough to attend, as the plants visited were modern in every respect.

Busses met the party at the Pennsylvania Railroad Station, and the visitors were taken to the Central Alloy Steel Corporation's plant at Massillon. Luncheon was served by the Central Alloy Steel Corporation in their spacious dining room, after which Mr. E. A. Portz, General Superintendent, honored the visitors with a word of welcome and a story of Stainless Steel.

Mr. B. F. Fairless, President of the Central Alloy Steel Corporation was introduced to the visitors.

Another pleasing feature of the luncheon was a lesson on "Safety," presented by Mr. J. A. Voss, Safety Director of the Central Alloy Steel Corporation, and Mr. M. P. Grady, Foreman of Shops, Pennsylvania Railroad at Canton. This feature was well received by the engineers, who were loud in their praise for the manner in which the skit was presented and the moral offered in the dialogue of these two prophets of Safety.

The Departments visited at this plant were the Power House, the Boiler House, Water Treating Plant, Coke Plant and Blast Furnace, Cast House, Gas Cleaning Equipment, Dust Recovery Equipment, Hot Metal and Slag Handling Equipment, Stock and Charging Equipment.

A short description of the plant is as follows:

The ore yard is 1212 feet long, has a storage capacity of 350,000 tons of ore, 50,000 tons of lime stone, and 75,000 tons of coal for coke ovens.

The car dumper has a normal capacity of twenty 100-ton cars an hour and weighs 400 tons. The bridge is 340 ft. span from leg to leg, with a cantilever over the bins of 68 ft., and a cantilever over the loading track at the opposite end of 15 ft., is equipped with a bucket of 10 net tons capacity—the bucket weighing 12 tons. The bridge weighs 1050 tons.

The bin system consists of one 400 ton central coke bin and 14 ore and stone bins—each with a capacity of 320 tons of ore. The ore bin gates are a modified roller type with the operating mechanism mounted on the 15 ton scale car. The transfer car holds 50 tons of ore. The coke breeze screened from the furnace coke bin is hoisted to the ore yard level by means of a skip hoist.

J. D. DONOVAN,
Superintendent, Mechanical, Electrical and Combustion Departments of Central Alloy Steel Corporation.

The furnace skip tubs of 165 cu. ft. capacity each are operated by an electric skip hoist. The bells are also operated by electric hoists.

The furnace is of 600 tons normal capacity. It has 18′-6″ hearth dia., 22′-6″ bosh, 17′-0″ dia. stock line and is 92′-0″ high; is equipped with a modern top and is fitted with a mud gun and cinder botter.

The four, two pass, stoves are 103 ft. high, 23 ft. dia. of shell, with 4″ checker opening and 2½″ brick with 81,300 sq. ft. of heating surface and have gas burners and hot blast valves. The stove chimney is 8′-0″ dia. at top and 225′-0″ high.

The blast furnace gas travels from the furnace to the dust catcher, through the water seal, whirler, washer, dryer and heat exchanger.

In the heat exchanger the temperature is raised about 50 degrees to eliminate sludge and goes on through a brick lined main to the boilers and an unlined main to the stoves.

The dust separated from the gas is taken from the bottom of the dust catcher and whirler by pug mills which deliver into an elevator which elevates it to a storage bin at the Sintering Plant. A track hopper is also provided into which general plant dust or coke breeze can be dropped and elevated to the bin, which is provided with two compartments, one for dust and one for breeze.

Bell valves are also provided in the bottom of the dust catcher and whirler to deliver to cars in case the Sintering Plant is not operating.

The sintering machine is of continuous design, 42″ wide and 25′-6″ long with a capacity of 6 to 7 tons per hour.

The gas washer sludge flows to the thickener from which it is pumped to the filter in the sintering plant.

The pig machine is 140 ft. long with 296 cast iron chilled moulds in each of the two strands.

Hot metal is handled in three 150 ton capacity ladles, lined with brick blocks 12″ thick.

The four slag cars are 330 ft. capacity, equipped with a steam dump.

The six Stirling type boilers have 8900 sq. ft. of heating surface and 4600 sq. ft. of surface in the economizer section at the rear, are built for 300 lbs. working pressure with 150 degrees superheat. Five of the boilers are fitted with pulverizers and water screens, and the sixth is equipped with a stoker for coke breeze and coal, driven by an engine. The fan is driven by turbine.

Each of the five boilers equipped for burning powdered coal is also fitted with two gas burners for blast furnace gas. Hollow walls are provided through which the air is drawn into the box girders supporting the boilers by a fan which delivers it to the air side of the gas burners, giving pre-heated air for combustion with the pre-heated gas. It is not the intention to burn both powdered coal and blast furnace gas on the boilers at the same time, except in an emergency, and provision is made to draw the pre-heated primary air from the side walls into the pulverizers to aid pulverization and increase combustion efficiency. The balance of air required for complete combustion is admitted through ports in the front wall and is controlled by a control system.

The five boilers are equipped with double compartment ash hoppers and the coke breeze boiler with a single compartment hopper.

The coal is dumped into a track hopper, through a crusher, onto a belt which delivers over a magnetic pulley into a pit, from which it is taken in a 2-yard bucket by a 5-ton crane to the overhead storage bin. The ashes are dropped into a small hand car which delivers to a pit from which the coal crane delivers into cars.

The steam pressure is controlled by a modern control system and the main steam valves are also fitted with a control system.

The 10,000 K.W.—Bleeder type turbine generator —1800 R.P.M., 80% P.F., is built for 275 lbs. working pressure and 150 degs. superheat. It generates at 11,000 volts, 3 phase, 60 cycles, at which the power is transmitted by the double power line to the mills where it is stepped down to 2300 volts and 220 volts for mill use. The condenser has 14,400 sq. ft. of heating surface.

The blowers have a maximum capacity of 60,000 cu. ft. of wind per minute and a maximum pressure of 35 lbs. The condensers have 6400 sq. ft. of heating surface.

The Spray Pond is 167 ft. by 375 ft. and is fitted with 700 nozzles each good for 40 gals. per minute

with 7 lbs. pressure. The Spray Pond water is used in the furnace cooling plates, condensers and bearings.

The continuous water treating system will soften 60,000 gals. per hour with a lime treatment for spray pond make-up. Lime treated water is put through a process for boiler feed make-up. The raw water from the river is of 23 grains hardness, about half carbonates and half sulphates.

Raw water is taken from four 24" wells, 120 ft. deep, driven along the river bank into the gravel bed where there is an abundance of water. The water filters through the gravel into the lower 60 ft. of the casing, which is fitted with a screen. The three 3500 G.P.M. motor driven pumps draw from a suction main connecting these wells and deliver through a 24" cast iron pipe to the furnace site.

The Coke Plant consists of 49 ovens, and have a capacity of 13.5 tons of coal each, 14" average width, 2' taper and 12'-6" high.

It is designed to produce 700 tons of coke on a 14 hour coking time.

A complete By-Product and Benzol Plant is also installed.

The gas is purified and piped to the Open Hearth where it is burned with oil and tar.

J. D. Donovan, a member of the Association is Superintendent of the Mechanical, Electrical and Combustion Departments of the Central Alloy Steel Corporation. Mr. Donovan was General Chairman of Arrangements during the trip through the Central Alloy plant. The manner in which Mr. Donovan and his aides handled the immense crowd on the trip through the plant caused much favorable comment from the visiting engineers.

At 3:30 p. m., the engineers were transported in busses to the Timken Roller Bearing Company's Plant at Canton, and the following departments were visited: Melting Department (electrical and open hearth furnaces), Soaking Pits, 35" Mill, 28" Mill, 22" Mill, Piercing Mill, 12" and 10" Mill, Roll Heading, Tube Finishing and Heat Treating.

The 35" Blooming Mill has one three high stand and is driven by a 1500 HP., 2300 Volt slip ring Induction Motor. Anti-friction Bearings are used on the roll necks of this mill.

There are two forty ton continuous triple fired reheating furnaces used to heat the blooms for the 28" Mill. The 28" Mill is a two stand three high mill having two tilting transfer tables. This mill is driven by a 1500 HP., 2300 Volt slip ring induction Motor through a 1500 HP Gear Reduction unit.

The 22" Mill consists of three, three high stands, and one, two high stand. This mill is driven by a 2,000 HP., 240 Volt DC motor through a 1500 HP Herringbone Reduction Gear unit.

The Tube Mill consists of two twenty-ton reheating furnaces, a thirty-six inch piercing mill driven by two, two hundred thirty volt DC Motors, with armatures in tandem, which gives a total rating of 4000 HP for the Mill.

The Rod Mill consists of a 16 stand merchant mill. The roughing stand is driven by a 600 HP synchronous mill type motor. A number of the stands are driven in groups of two by a 1200 HP. synchronous motor and 600 HP. DC motors respectively. Of the Belgian Mills, the first, consisting of two stands, is driven by a 1200 HP., DC Motor. The second of four stands, by a 1200 HP., DC Motor and the third of two stands, by a 400 HP., DC motor. All drives are through reduction gear units. After the product passes through the continuous stands the work is delivered to the various groups of Belgian stands by an elaborate system of rope transfer tables and runout tables.

There are quite a number of electrically heated furnaces for annealing purposes, ranging from 100 KW to 850 KW in size. The total connected furnace load of these furnaces is over 6000 KW.

Many of the engineers were very much interested with the operation of the electric furnaces. There are four Heroult Electric Arc Furnaces in this plant. They range in size from 7½ tons to over 50 tons.

One of the Electric Arc Furnaces in the Timken Plant.

There is also three open hearth furnaces very modern in construction. All of these furnaces, both electrical and open hearth, are charged by two five-ton floor type charging machines.

The visitors were also taken through the Roller Bearing Factory, which was one of the interesting features of the trip.

During the inspection trip through the Central Alloy Steel Corporation plant, the visitors were very much impressed by the various safety signs posted throughout the plant. A number of these signs are reprinted on the following pages. These Safety Rules are very complete and may be of some help to our readers in the compilation of Safety Rules for their plants.

HIGH VOLTAGE RULES

CENTRAL ALLOY STEEL CORPORATION
MASSILLON, OHIO

RULE 1.

WORKING ON HIGH VOLTAGE.

Anyone who is required to work on High Voltage (Defined as 2200 volts or higher) must get in touch with his Electrical Foreman. The Electrical Foreman will be entirely responsible for clearing the line, and for the safety of his men.

RULE 2.

LOCKING OUT DISCONNECTS.

Before men work on High Voltage lines or equipment, breaker must be opened and disconnects must be locked out by use of disconnect lockout.

RULE 3.

GROUNDING.

Before starting work on High Voltage all conductors leading to the point where work is to be done must be tested with voltage indicator, grounded and shorted. Standard ground stick or chain is to be applied, first to the ground connection, then to conductor as close to point of work as possible.

RULE 4.

CLEARING THE LINE.

The Electrical Foreman must assure himself that every man is off the line before removing grounds, and all grounds must be removed before disconnects are unlocked.

RULE 5.

RESTORING POWER.

The Operator in charge of equipment which was shut down must be notified by the Electrical Foreman who was working on lines or equipment when same is clear for restoring power.

IMPORTANT.

Employes should bear in mind that accidental contacts with any high voltage circuits are very dangerous, and they should not touch any conductors carrying high voltage.

There are many special conditions which make electrical work dangerous. It is impossible to explain in detail all such possible cases, but competent workmen are always careful. When in doubt, consult your Foreman.

NOTE—When power is to be interrupted at Canton Works on 11,000 or 22,000 v. lines, load dispatcher at 35″ Mills Sub-Station is to be notified before starting, and when work is completed.

Effective January 1st, 1928

CENTRAL ALLOY STEEL CORPORATION

MASSILLON, OHIO

MACHINE SHOP SAFETY RULES

1. No one should operate any machine unless instructed to do so. Never meddle around machinery.
2. Never work on a crane, table or other machinery until you have notified the operator to shut off the power and secured a lock and sign, "Danger—Do Not Move, Man on Machine" at the point where the power is turned on. No man, except the man who placed it, should ever remove lock and sign.
3. Employees working around machinery should use great care and not wear gloves, jewelry or unsuitable clothing, such as ragged sleeves, loose coats, ties or jumpers, as there is danger of same getting caught in the machinery.
4. Operators of machines should pay strict attention to their duties. Use special care when operating high speed machines.
5. Men working on lathes, drill presses and machines of all kinds must inspect same every day before starting to work and report defective conditions to their foreman.
6. When removing drillings from job at drill, or shavings from lathe, milling or other machine, stop the machine or use brush to remove drillings and shavings.
7. Shafts or other machinery resting on horses should be well blocked and horses placed close enough together so that job will not fall off or between the horses.
8. Machine operators must use chip guards to prevent chips flying from machine.
9. Securely fasten work under drill press before drilling it. Never attempt to hold work being drilled as it may fly around and injure you.
10. Never start any machine unless your work is securely fastened down.
11. When tightening drill in chuck of drill press remove key before you start machine or your arm may be twisted around spindle. Never leave key in chuck.
12. Never place hands on chuck rims when lathe is in motion.
13. Steady rests on big lathes should never be left extending over passageways.
14. Don't attempt to screw chuck on lathe spindle when machine is in motion, as it may get cross threaded and cause an accident. Use a board under chuck and screw on when machine is stopped.
15. Always take machine tool out of tool post as soon as you are done using it as you are liable to get cut while removing job from machine or put a bad mark on finished work.
16. When filing work in lathe, file with your right hand over lathe instead of left hand. Never use a file without a handle and see that handle is secure.
17. Don't place anything so near planer that the table will not have two feet clearance at its longest stroke.
18. Watch out for work that overhangs planer table. Never place your head down too close to work when table is moving as you may get crushed between work and cross rail.
19. Always have clearance between cross rail and work for a man's arm.
20. Never ride on planer table as platen dogs may slip and you will be caught. See that job is securely blocked and tightened.
21. Never place head or hands over work in slotter as hammer is liable to catch you.
22. Never attempt to change the speed of a belt with your hand while same is in operation as your hand may get caught between belt and pulley.
23. A safety type of lathe dog should be used on all lathes.
24. After repairing machinery, always replace safeguards before leaving the job.
25. Operators of machines are warned not to attempt to repair machines,—Call your foreman. Stop all machines before oiling, wiping or repairing.
26. Mechanical men should be conversant with the rules applying to the department in which they work.
27. When you complete a job, NEVER leave tools or other material lying overhead. Tear down all temporary scaffolds as soon as you are through with them. Do not allow boards with nails sticking up to lie around anywhere.
28. Before going in an engine or pump, block the flywheel or cross-head to prevent a leak of steam or an overbalance starting engine.
29. Do not work near live wires without having them insulated by an electrician.
30. All punches, shears or other machines which are set in motion with tripping device, when not in use, or when being adjusted or repaired, must have the power shut off or be securely locked or blocked.
31. Do not work with defective chains, cables, tools or appliances of any kind, or in an unsafe place. Carefully examine and report dangerous conditions to your foreman.
32. Always use good judgment in hooking up a lift. Be sure that cable or chain cannot slip. Inspect your lift before you allow it to go over machines or men. See that cables and chains are strong enough to handle lift.
33. Do not turn on any electricity, gas, steam, air, acid or water, or set in motion any machinery, or throw down any material, without first seeing if anyone is in a position to be injured, and that all safety guards are in their proper places.
34. Do not go onto an overhead crane runway, for any purpose, without permission from your foreman, and then not until the craneman has been notified. After notifying craneman attach bumping block to crane rail between where you are working and cranes. Use same precaution when working near crane tracks.
35. Wear goggles when working around circular saws, chipping, handling acid, cutting cables, working at emery wheels, etc.
36. Do not ride on, or operate engines, cars, cranes, elevators or other moving bodies, or tamper with electrical apparatus, unless authorized to do so. Never leave your regular place of work except when required by your duties.
37. If you make an opening or remove the cover from any opening in floor, ground, valve pit or sewer, guard that opening so no one can fall into it.
38. Do not pile any material so high that it is liable to fall, or cause any other pile to fall, or allow it to lean against walls too weak to bear the pressure.
39. Whenever men are working overhead they must not drop any material without giving warning to those below. When it is necessary to work above or below other men, those men should be notified. Men working overhead shall place a sign, "Danger—Falling Material," on ground below them. When light is not sufficient to enable these signs to be readily seen a red lantern must be placed thereon.
40. Don't move heavy loads over floors until you find out that floors are strong enough to sustain the load.
41. Employees are forbidden to take short cuts across dangerous places. Do not go through Boiler Houses, or Mills on your way to or from work, or any other time, unless your duties take you there. Go by the road.
42. Every employee should report promptly to his foreman any defective condition affecting the safety of any employee.
43. If you are injured, no matter how little, tell your foreman about it right away, and go to the Hospital. A slight injury may cause blood poison.
44. If in doubt as to the meaning of any rule, apply to your foreman for an explanation. Always take the safe course.
45. Do not try to use cutting or welding torch unless you are fully familiar with same and until you have the consent of your foreman to use same.
46. Horse play and fooling are very dangerous, and will not be allowed in this Department.
47. Commit no nuisance, be clean and help to keep the plant clean.

The above rules are based upon experience. Read them over carefully. If you are not willing to give your hearty co-operation and live up to these rules, we wish you would voluntarily leave the employ of the company, as if we discover anyone intentionally violating them his employment will be summarily ended.

CENTRAL ALLOY STEEL CORPORATION
MASSILLON, OHIO

Safety Rules Governing Locomotive Crane Operators and Brakemen

1. All locomotive cranes shall be equipped with steps and hand-holds opposite the door, to give safe and convenient access to the cab. Steps and hand-holds shall not be allowed on any other part of crane. Footboards shall NOT be allowed on cranes.
2. Do not allow anyone to ride on deck of crane under any circumstances. Refuse to move.
3. Only authorized operator, brakeman or fireman shall be permitted to ride in crane cab, but under no circumstances shall they be permitted to ride on deck of crane. This same rule shall apply to authorized repairmen.
4. No one shall be permitted to ride on journal boxes or any other part of the crane.
5. When heavy loads are to be handled where there is any danger of tipping, use out-riggers and block firmly underneath same, making car body as near level as possible by driving wooden wedges underneath same. If crane is not provided with outriggers, block it up properly. Do not depend on rail clamps for heavy lifts.
6. See that boom is not too low, but when traveling around yard, see that it is low enough to clear all wires, bridges, etc.
7. Operators must not swing crane when traveling, unless required to do so in the handling of material.
8. Operators should examine crane every turn for defective apparatus or things liable to cause an accident and report all defects to foreman immediately in writing on Form T-1612.
9. Authorized repairman shall inspect entire crane, including cables, before crane is sent out on a heavy lift.
10. Operators must display head and tail lights on cranes, and see that they are lighted and remain so during the night whenever conditions require.
11. Operators shall observe signals only from persons duly authorized for crane service and under no circumstances shall a load be moved until the signal is received from the proper man.
12. Locomotive cranes must not be swung across railroad track, or into such position that cars moving on that track could strike it, until crane operator and brakeman have made sure cars are not being moved on that track. If there is danger of trains moving on track, set flags to protect crane during day and lights at night.
13. Crane operators must never lift a load which in their opinion is unsafe for the capacity of their crane, which, of course, depends on the angle of the boom.
14. Operators shall never take any chances under any circumstances on low water in boiler.
15. Brakeman shall not be allowed to stand or walk underneath boom at any time, except as required to hook-up or unhook load.
16. Brakeman shall carry lantern when working at night.
17. Brakeman must not go between moving cars to make a coupling.
18. Operators and brakemen must thoroughly familiarize themselves with hand, flag and lamp signals, and engine whistle signals as used by the Transportation Department.
19. Do not swing crane with boom at short radius and no load on boom, as crane is liable to go over backwards.
20. In making minor repairs, adjusting frictions, or any other work which requires coming in contact with the machinery, operator must see that main valve to boiler is closed and that throttle cylinder cocks are open, so that any steam which might leak through can escape. If necessary, block cross-heads so that there is no danger of engine starting to run while men are working on machinery.
21. No lift shall be made at any time by any crane having chains or slings suspended from or through clam shell bucket.
22. Buckets and magnets must be lowered to ground when not in use.
23. Use the best of judgment at all times, as you are responsible for the machine.

Effective May 1st, 1929

Items of Interest

PERSONNEL CHANGES

Mr. M. E. Danford, for more than seven years Works Manager of the Middletown Division of The American Rolling Mill Company has been appointed Assistant Vice President of that company, according to an announcement issued October 4th by Mr. Charles R. Hook, Vice President and General Manager.

Mr. Danford started his career with Armco February 1, 1910, when he came to Middletown as superintendent of the Open Hearth Department of the Central Works plant. In that capacity he helped to plan and supervise the building of the open hearth furnaces at the East Works plant.

In July, 1911, when the new plant at East Works was ready for operation, Mr. Danford was made Assistant to Mr. Charles R. Hook, then General Superintendent of The American Rolling Mill Company. In July, 1916, when Mr. Hook was made Vice President and General Manager, Mr. Danford was made General Superintendent of the Middletown Division. He was appointed Works Manager of that division in 1921, which includes the Zanesville plants as well as those of the company in Middletown.

The Trumbull Electric Manufacturing Company advises of the appointment of Mr. H. L. Wheeler as Manager of their New York district office, as of October 9th, taking the place of Mr. A. H. Bergendahl, whose sudden tragic death occurred in Richmond, Virginia, October 3rd.

Mr. Wheeler has been with the Trumbull Company for many years, and has represented them in the Maryland, Washington, D. C., and North Carolina district.

The Trumbull Electric Manufacturing Company also wishes to advise of the appointment of S. B. (Ben) Hallberg as Branch Manager of the Chicago office, in place of M. L. Spaulding, who has resigned as of November 1st, to assume the position of Central District Managare of the General Electric Supply Corporation, Chicago.

Mr. Halberg for many years has been Resident Manager of the metropolitan Chicago district, and has a wide circle of acquaintances and friends.

The Champion Switch Company, Kenova, West Va., announce that J. A. Dudley, formerly of the Chrysler Corporation is now at Kenova in charge of production.

Jones & Laughlin Steel Corporation have announced the appointment of new department and mill heads. Mr. F. E. Fieger has been appointed manager; Mr. J. G. West, Jr., assistant general man-General Manager; Mr. J. Z. Collier, assistant general ager; Mr. C. M. White, general superintendent, Aliquippa works; Mr. Harry Saxer, assistant general superintendent, Aliquippa works; S. S. Marshall, Jr., general superintendent Pittsburgh works; H. D. Stark, assistant general superintendent in charge of North Side Works.

The Champion Switch Company, Kenova, West Va., also announces that Rudolph J. Stewart, formerly with the West Penn Power Company in charge of inspection and construction work, is now with the Champion Switch Company in charge of the inspection department.

At the meeting of Pittsburgh Steel Company, W. C. Sutherland was elected a director.

Mr. T. M. Girdler, President of Jones & Laughlin Steel Corporation, and Mr. R. J. Wysor, General Manager of the Corporation, have resigned to become associated with the Otis-Eaton-Mather steel interests of Cleveland.

Mr. Henry J. Freyn, President of the Freyn Engineering Company, returned from a trip abroad, October 18th. Mr. Freyn has been in the U. S. S. R. for the past three months in connection with consulting work which this company is doing for the Iron and Steel Industry of the Soviet Government.

Weirton Steel Company of Weirton, W. Va., have announced the following changes of executive personnel. J. C. Williams has been elevated from Vice President to President; the vice presidents are H. D. Westfall and T. A. Hanlin; W. A. Murphy is secretary, succeeding T. A. Hanlin. C. H. Hunt is assistant to the president.

C. H. Hunt is a member of the Association of Iron and Steel Electrical Engineers, and the Association members are extending their best wishes for his continued success in his new work. He is a member of the Association's Development in Rolling Mill Practices Committee and a member of the Furnace Section Committee of the Combustion Engineering Division.

Mr. P. J. Hale sails October 25th on the Bremen for England. Mr. Hale will be resident engineer for Freyn Engineering Company in connection with the blast furnace plant to be built near London for the Ford Motor Company.

NEWS FROM THE MANUFACTURERS

NEW M-S-A GENERAL CATALOG

The Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh, Penna., has just issued their new No. 4 General Catalog of one hundred sixty pages, covering "Everything for Mine and Industrial Safety." Copies will be furnished gratis to all those interested in the safety and welfare of employees, upon application to the Advertising Department.

FORD TO INSTALL WORLD'S MOST MODERN TURBINE GENERATOR

The most modern turbine generator so far conceived, rated 110,000 kilowatts, is to be installed by the Ford Motor Company in the power generating station of its River Rouge plant at Fordson, Michigan. This machine, involving many novel and unusual features of design, will represent the last word in up-to-date generating equipment. Its tremendous electric output, far exceeding the rating of any existing prime mover used for industrial purposes, will be used in the manufacture of Ford automobiles.

The new machine represents interesting departures in design and construction. It is a vertical compound unit and is the first large machine to be made to this design. The high-pressure turbine and generator will be mounted directly on top of the low-pressure turbine and generator, resulting in the most compact unit yet proposed. Each element has a capacity of 55,000 kilowatts.

One of the important features of the design—of particular value in the Ford plant, where floor space is at a premium—is the small amount of space which will be taken up by the new unit. The general dimensions include a length of 57 feet 6 inches, a maximum width of 23 feet and a little less than 21 feet overall height from the floor. The approximate weight is 2,000,000 pounds. The space to be occupied is less than a quarter of a cubic foot per kilowatt of output.

Two older generating units, rated 12,500 kilowatts each, are to be moved out to make room for the new machine. The superseded turbine generators were built and installed by the General Electric Company in 1921 and have given excellent service since installation. Striking evidence of the improved design of the new machine is that, in spite of its tremendously greater output, it will occupy approximately the same floor space in the power plant as did the two older units and produce, instead of 25,000 kilowatts, 110,000 kilowatts. Considerably more than twice as many kilowatts will be generated for a square foot of floor area than in any other recent large power installation.

The new machine will use approximately 50% less coal to produce a given number of kilowatt-hours than the units which will be removed, and it will require less than a pound of coal to generate a kilowatt-hour of electricity.

The new machine was designed and is being built by the General Electric Company at its Schenectady Plant. According to E. E. Gilbert, manager of the turbine sales department, the turbine design involves all the features now known to the art which will increase the economy and reliability. It will be installed and put in operation in 1930—an unusually short time for such a large and unusual machine. Its complete technical rating is 110,000 kilowatts, 90% power factor, 13,800 volts, 1800 r.p.m., 3-phase, 60 cycles, with steam conditions of 1200 pounds gauge pressure; 725 deg. F. total temperature; reheat to 550 deg. F., and one inch vacuum.

Steam will enter the upper turbine unit at 1200 pounds pressure and, after producing 55,000 kilowatts, will flow into reheaters. In these reheaters steam at 1200 pounds pressure direct from the boilers will reheat the steam exhausted from the high-pressure turbine which will then flow down and into the low-pressure unit, where it will produce another 55,000 kilowatts.

Air coolers will be built integral with the generators and will be connected so that the heat losses in the generators will be recovered and returned in the feed water. The combination of all these elements—the large 1200-pound turbine, the steam reheat, the economies of compact design—will result in one of the most efficient steam stations in the world.

To supply cooling water for the new unit a tunnel will be constructed connecting the River Rouge with the Detroit River. This tunnel will be 3½ miles long, 15 feet in diameter and will deliver 600,000,000 gallons of water every 24 hours.

Some interesting comparisons have been made involving the Ford car in whose manufacture the power from the new unit will be used. The output of the new turbine exceeds that of approximately 6,000 Ford engines. The weight of the turbine generator is equivalent to approximately 855 Ford sedans and the floor space occupied would provide parking space for only 17 Ford cars.

It is pointed out, as a matter of interest, that years ago Henry Ford operated engines in the power stations of the Detroit Edison Company, while now he is buying, with his own money and for his own use, one of the most powerful high-pressure turbine generators conceived in the world today.

A NEW BEARING BY NEW DEPARTURE

A self-sealed, self-lubricated ball bearing which reduces mounting costs and at the same time increases bearing efficiency in service life is announced by the New Departure Manufacturing Company of Bristol, Connecticut.

The N-D-Seal bearing, as it is called, is made only in the smaller sizes and consists of what is essentially a New Departure single row ball bearing of the non-loading groove type, permanently fitted into a metal case or shell.

This shell is shaped on one side of the bearing so as to contain a felt closure which fits over the ground outside diameter of the extended bearing inner ring, thus forming an efficient seal both for the retention of lubricant and the exclusion of dirt.

While the inner ring is carried slightly beyond the face of the seal so as to facilitate removal of bearing without damage and to prevent interference between shaft shoulder and seal, the overall width of the new bearing is much less than the space occupied by a standard bearing of the same size, together with a separate closure member. Outside diameters and bores are standard.

The capacity characteristics of this bearing are substantially the same as corresponding sizes of non-loading groove Single Row bearings, which means that they are capable of resisting a comparatively high amount of thrust in combination with radial load.

A NEW D.C. ACROSS THE LINE STARTER

A new, automatic, across-the-line starter, for general applications of direct current motors up to 2 H.P., 115 or 230 volts, is announced by Cutler-Hammer, Inc., 157 12th street, Milwaukee, Wis. Some new and important features incorporated in this new design are: small size, low cost, double line break, thermal overload protection, low voltage protection, silver contacts, and completely enclosed structure. Two magnetic contactors, one in each side of the line, connect the motor directly across the line on starting and provide a double line break. The contactors are designed especially for direct current service. They have renewable silver contacts, and a heavy stamped frame.

The thermal overload relays are the same as those used in this Company's A. C. across-the-line starters for small motors. They are the fusible alloy type and can be adapted to any size motor by simply changing heater coils. When tripped by an overload, the relays are reset by pushing a button in the cover.

Each starter is furnished with a pushbutton master switch providing three-wire control. This master switch can be furnished mounted in the cover of the starter, or it can be arranged for mounting separately. These starters are also made without the thermal overload relays, for applications where overload protection is not required.

A NEW ENGINEERING SERVICE MADE AVAILABLE BY AN IMPORTANT MERGER OF WELDING MACHINE COMPANIES

A consolidation of the Thomson Electric Welding Company of Lynn, Massachusetts, and the Gibb Welding Machines Company of Bay City, Michigan, has been announced, the new company to be known as the Thomson-Gibb Electric Welding Company. Both plants will continue in operation.

The Thomson Company is the pioneer resistance welding company, having been formed in 1886 to exploit the basis resistance welding patents of Professor Elihu Thomson of Lynn, Massachusetts. Professor Thomson has always been an officer and director of the Thomson Company and will continue with the new company in both capacities.

The Gibb Company has been one of the most active of the Western companies and has specialized in seam welding.

The Thomson-Gibb Electric Welding Company offer a full line of butt, flash, seam, spot, projection and wire fabric welders, together with expert service designed to secure uninterrupted production and uniform quality from its machines in the hands of manufacturers.

Thomson and Gibb companies to improve the exist-

For some time past it has been the desire of the ing system of distribution of welding machines. It is pointed out that the user of welding machines is not so much interested in the welding machine as in the product of that machine, both from the standpoint of uniformity of product, and from the standpoint of uninterrupted production.

The welding machine is but one of many special machines in a manufacturing plant. It is impossible to have in an organization an individual who would be as well acquainted with the welding machine itself and its ultimate capability as the manufacturer of that machine. Therefore, the missing link is the service engineer to make frequent inspection calls and to act in an advisory capacity. It is this link which the new company proposes to adequately supply.

With the consolidation of the Thomson and Gibb companies a new and complete engineering service is made possible through the maintenance of local service engineers to insure the maximum production from every Thomson-Gibb machine. The Thomson-Gibb Electric Welding Company expect to immediately place competent engineers direct from the factory at Boston, New York, Philadelphia, Cleveland, Cincinnati, Detroit, Chicago and St. Louis. Such addition to this staff will be made in the future as may be required to keep all machines operating at their maximum efficiency.

WESTINGHOUSE AWARDED LARGE STEEL MILL ORDER

The Westinghouse Electric & Manufacturing Company recently received an order for all the electrical equipment for the main drive of a beam mill to be installed at the South Works for the Illinois Steel Company at South Chicago, Illinois.

This mill will be used to produce a wide flange Section which differs from the standard I beam in that the flanges are of uniform thickness instead of being tapered, and the thickness of the metal in the flanges can be varied over a wide range.

Special engineering study has been given to this mill and several modifications have been made in usual mill and electrical designs.

An example of this is shown in the case of the two 5000 H.P. reversing motors to be used on a 54-inch reversing blooming mill. Heretofore, in reversing mill drives, one motor was used to drive both rolls of the mill through a pinion housing which transmitted power from the motor shaft to the top and bottom rolls. Since the pinion housing represents a considerable initial expense and was costly to maintain, the mill design was modified and two individual 5000 hp. motors were used. Each will be directly connected to one roll, thereby eliminating the pinion housing. The control will be so arranged that these motors will each maintain their proper speed relations at varying speeds as well as take their proper share of the load.

The entire mill has been gone over from the same standpoint, and as a result, special features of design will be incorporated in the equipment to be supplied. When the mill is completed, it will be the most nearly automatic mill in the world.

A BETTER MULTIPLE RETORT STOKER

The C-E Multiple Retort Stoker possesses important advantages of design and construction which are evident to those who have had the opportunity to examine it. • The character of its performance is revealed in the operating records of existing installations. • Translated into actual performance, the results of the many new features embodied in this stoker are —

NOTABLE SMOOTHNESS AND RELIABILITY OF OPERATION • LOWER AIR PRESSURES
EASIER AND MORE ACCURATE CONTROL OF MOVING PARTS
HIGHER FUEL BURNING CAPACITY • IMPROVED OPERATING EFFICIENCY
MORE EFFECTIVE ASH DISPOSAL • LOWER MAINTENANCE COSTS

Because of these results, the performance of the C-E Multiple Retort Stoker represents a definite advance over present-day standards in the multiple retort stoker field.

• • •

Your copy of the new catalog, describing the C-E Multiple Retort Stoker, is awaiting your request.

COMBUSTION ENGINEERING CORPORATION
International Combustion Building • 200 Madison Ave., New York
A SUBSIDIARY OF INTERNATIONAL COMBUSTION ENGINEERING CORPORATION